105939

Table 6-7 (continued)

Distribution of Chemicals Detected in Groundwater Samples (Shallow Wells) Collected from the Dorney Road Landfill and Background Concentrations

Dorney Road RI

	Frequency of Detection[a]	Number of Estimated Values[b]	Geometric Mean	Maximum	Background Range[c]
Cobalt	6/6	1	22.47	402.5	47
Magnesium	6/6	1	47,274	285,500	30,400
Calcium	6/6	1	79,643	568,000	55,300
Sodium	6/6	1	16,372	1,110,000	4740
Potassium	6/6	1	4581	6430	4040
Cyanide					

[a]Number of times detected/number of samples (total number of samples may vary as a result of validation or number of samples analyzed).
[b]Concentrations reported with J qualifier.
[c]If a chemical was not detected, the detection limits are presented.

NA = not applicable. Only detected in one sample, and use of one-half of the detection limit in calculating the mean results in a mean concentration that is less than the detection limit.

Table 6-8

Distribution of Chemicals Detected in Groundwater Samples (Deep Wells) Collected from the Dorney Road Landfill and Background Concentrations

Dorney Road RI

	Frequency of Detection[a]	Number of Estimated Values[b]	Geometric Mean	Maximum	Background Range[c]
ORGANICS			(all concentrations in ug/l)		
Methylene chloride	1/4	0	NA	14	< 5
Benzene	1/4	0	NA	6	< 5
1,1-Dichloroethane	2/4	2	2.65	4	< 5
Tetrachloroethylene	2/4	1	2.73	9	< 5
Toluene	2/4	0	6.59	43	< 5
1,1,1-Trichloroethane	1/4	1	NA	1	< 5
Trichloroethylene	1/4	0	NA	15	< 5
Vinyl chloride	1/4	1	NA	1	< 10
Acetone	2/4	1	9.72	21	< 10
1,2-Dichloroethene	2/4	1	4.0	41	< 5
Bis(2-ethylhexyl)phthalate	2/4	0	12.65	33	< 10
INORGANICS			(all concentrations in ug/l)		
Arsenic	2/4	0	2.90	1.9	< 10
Beryllium	1/4	0	NA	2.6	< 5
Chromium	1/4	0	NA	7.9	6.6
Copper	2/4	0	15.60	20	< 25
Lead	4/4	0	11.7	21	8.6
Mercury	1/4	0	NA	0.94	< 0.2
Thallium	1/4	0	NA	2.3	< 10
Zinc	4/4	2	136.56	240	13
Barium	4/4	0	55.81	82	9.3
Iron	4/4	0	1746.65	12,800	409
Manganese	3/3	0	88.68	489	< 15
Vanadium	4/4	0	6.51	15	3.6
Cobalt	4/4	0	6.62	8.6	< 50
Aluminum	4/4	0	510	2670	< 200
Magnesium	4/4	0	14,059	50,700	<5000
Calcium	4/4	0	52,022	90,200	<5000
Sodium	4/4	0	5470	12,600	<5000
Potassium	4/4	0	5216	8620	<5000

[a]Number of times detected/number of samples (total number of samples may vary as a result of validation or number of samples analyzed).
[b]Concentrations reported with J qualifier.
[c]If a chemical was not detected, the detection limits are presented.

NA = not applicable. Only detected in one sample, and use of one-half of the detection limit in calculating the mean results in a mean concentration that is less than the detection limit.

Table 6-9

Distribution of Chemicals Detected in Surface Water Samples Collected from the Dorney Road Landfill and Background Concentrations

Dorney Road RI

	Frequency of Detection[a]	Number of Estimated Values[b]	Geometric Mean	Maximum	Background Range[c]
ORGANICS		(all concentrations in ug/l)			
Chloroethane	1/5	0	NA	11	< 10
1,1-Dichloroethane	1/5	0	NA	9	< 5
Ethylbenzene	1/5	1	NA	3	< 5
Toluene	1/5	0	NA	8	< 5
1,1,1-Trichloroethane	1/5	1	NA	2	< 5
Acetone	2/5	0	7.1	12	< 10
INORGANICS		(all concentrations in ug/l)			
Arsenic	1/5	0	NA	1.7	< 10
Chromium	3/5	0	6.5	9.95	5.1
Lead	3/5	0	8.8	30	< 5
Zinc	5/5	0	19.1	34	4.9
Barium	5/5	0	71.8	580	1.8
Iron	5/5	5	3031.5	85600	< 100
Manganese	5/5	0	1083.0	31000	< 15
Vanadium	5/5	0	6.7	19	< 50
Aluminum	4/5	0	190.5	1460	< 200
Cobalt	5/5	0	16.8	133	< 50
Magnesium	5/5	0	11222.8	23050	194
Calcium	5/5	0	23228.1	77300	< 5
Sodium	5/5	0	11035.2	21350	<5000
Potassium	5/5	0	12525.5	22350	<5000
Cyanide	1/5	5	NA	28	< 10

[a] Number of times detected/number of samples (total number of samples may vary as a result of validation or number of samples analyzed).
[b] Concentrations reported with J qualifier.
[c] If a chemical was not detected, the detection limits are presented.

NA = not applicable. Only detected in one sample, and use of one-half of the detection limit in calculating the mean results in a mean concentration that is less than the detection limit.

Table 6-10

Distribution of Chemicals Detected in Sediment Samples Collected from the Dorney Road Landfill and Background Concentrations

Dorney Road RI

	Frequency of Detection[a]	Number of Estimated Values[b]	Geometric Mean	Maximum	Background Range[c]
<u>ORGANICS</u>		(all concentrations in ug/kg)			
Chloroform	1/5	1	NA	6	< 5
Ethylbenzene	1/5	1	NA	4	< 5
Acetone	3/3	0		160	< 10
2-Butanone	1/5	1	NA	21	< 10
Bis(2-ethylhexyl)phthalate	1/5	1	NA	78	<330
4-Methylphenol	1/5	1	NA	52	<330
<u>INORGANICS</u>		(all concentrations in mg/kg)			
Arsenic	5/5	5	8.28	14.1	1.4 (estimated)
Beryllium	5/5	5	3.5	5.2	< 5
Chromium	5/5	5	8.7	11	7.8 (estimated)
Copper	5/5	0	25.6	99	< 25
Lead	5/5	5	21.8	95	< 5
Mercury	4/5	0	0.135	0.19	< 0.2
Nickel	5/5	0	47.9	52	< 40
Zinc	5/5	0	120.4	152	5.7
Barium	5/5	0	80.0	109	3.9
Iron	5/5	0	41,785.1	47,500	145
Manganese	5/5	0	1140.7	1600	1.1
Vanadium	5/5	0	24.4	34	15
Aluminum	5/5	0	12,179.8	17,600	185
Cobalt	5/5	0	29.5	36	< 50
Magnesium	5/5	0	1116.0	1640	304
Calcium	5/5	0	567.0	1105	1780

[a]Number of times detected/number of samples (total number of samples may vary as a result of validation or number of samples analyzed).
[b]Concentrations reported with J qualifier.
[c]If a chemical was not detected, the detection limits are presented.

NA = not applicable. Only detected in one sample, and use of one-half of the detection limit in calculating the mean results in a mean concentration that is less than the detection limit.

ORIGINAL (Red)

Table 6-11

Distribution of Chemicals Detected in Leachate Seep Samples Collected from the Dorney Road Landfill and Background Concentrations

Dorney Road RI

	Frequency of Detection[a]	Number of Estimated Values[b]	Geometric Mean	Maximum	Background Range[c]
ORGANICS		(all concentrations in ug/l)			
Chloroethane	1/2	1	NA	1	< 10
Toluene	1/2	0	NA	1600	< 5
Acetone	1/2	0	NA	6400	< 10
2-Butanone	1/2	0	NA	16,000	< 10
4-Methyl-2-pentanone	1/2	1	NA	390	< 10
Diethylphthalate	1/2	1	NA	560	< 10
Di-n-butylphthalate	1/2	1	NA	6	< 10
Naphthalene	1/2	1	NA	310	< 10
Phenol	1/2	1	NA	390	< 10
2-Methylphenol	1/2	1	NA	28	< 10
4-Methylphenol	1/2	1	NA	3700	< 10
Benzoic Acid	1/2	1	NA	2700	< 50
INORGANICS		(all concentrations in ug/l)			
Antimony	1/2	0	NA	163	< 60
Arsenic	2/2	2	47.7	242	< 10
Copper	1/2	0	NA	39	< 25
Lead	2/2	0	35.5	486	< 5
Nickel	1/2	0	NA	1610	< 40
Zinc	2/2	2	2510.1	71,600	< 20
Barium	2/2	0	373.3	489	< 200
Iron	2/2	0	100,150.9	2,190,000	< 100
Manganese	2/2	0	50,602.4	118,000	< 15
Vanadium	1/2	0	NA	4.4	< 50
Aluminum	2/2	2	418.4	612	< 200
Cobalt	2/2	0	118.9	785	< 50
Magnesium	2/2	2	51,899.9	259,000	<5000
Calcium	2/2	2	237,924.4	1,220,000	<5000
Sodium	2/2	2	54,902.9	737,000	<5000
Potassium	1/1	0	NA	669,000	<5000

[a]Number of times detected/number of samples (total number of samples may vary as a result of validation or number of samples analyzed).
[b]Concentrations reported with J qualifier.
[c]If a chemical was not detected, the detection limits are presented.

NA = not applicable. Only detected in one sample, and use of one-half of the detection limit in calculating the mean results in a mean concentration that is less than the detection limit.

ORIGINAL
(Red)

Table 6-12

Distribution of Chemicals Detected in Residential Water Samples Collected from the Dorney Road Landfill and Background Concentrations

Dorney Road RI

	Frequency of Detection[a]	Number of Estimated Values[b]	Geometric Mean	Maximum	Background Range[c]
ORGANICS		(all concentrations in ug/l)			
1,1-Dichloroethane	1/8	1	NA	2	< 5
Tetrachloroethene	2/8	0	2.71	6	< 5
Trichloroethene	1/8	0	NA	9	< 5
1,2-Dichloroethane	1/8	0	NA	22	< 5
Bis(2-ethylhexyl)phthalate	1/8	1	NA	2	< 330
INORGANICS		(all concentrations in ug/l)			
Zinc	5/7	5	26.43	448	< 20
Barium	7/7	0	13.30	31	4.1
Iron	6/7	0	33.75	179	< 100
Manganese	7/7	0	6.50	83	3.8
Vanadium	5/7	0	5.56	3.3	< 50
Magnesium	7/7	8	18,624	24,900	162
Calcium	7/7	0	46,525	119,000	285
Sodium	7/7	0	4601	18,400	<5000
Potassium	2/7	0	2852	5360	<5000

[a]Number of times detected/number of samples (total number of samples may vary as a result of validation or number of samples analyzed).
[b]Concentrations reported with J qualifier.
[c]If a chemical was not detected, the detection limits are presented.

NA = not applicable. Only detected in one sample, and use of one-half of the detection limit in calculating the mean results in a mean concentration that is less than the detection limit.

Table 6-13

Summary of Indicator Chemicals at Dorney Road Landfill Site

Dorney Road RI

Chemical	Soil On-site	Soil Off-site	Surface Water	Sediment	Subsurface Soil On Waste	Subsurface Soil On Natural	Subsurface Soil Off-site	Ground-water	Residential Wells	Seep
ORGANICS										
Benzene	X				X	X		X		
Chlorobenzene	X	X			X	X	X	X		
Chloroform	X	X		X	X	X	X	X		
Tetrachloroethene					X	X		X	X	
Ethylbenzene	X		X	X		X		X		
Trichloroethylene						X		X	X	
Styrene						X		X		
4-Methyl-2-pentanone	X				X	X		X		
PAHs (carcinogenic)	X				X	X	X			
Bis(2-ethylhexyl)phthalate	X	X		X	X	X	X	X	X	
1,4-Dichlorobenzene	X				X	X		X		
Diethylphthalate	X				X			X		
Di-n-Butylphthalate	X				X	X	X			
Vinyl chloride								X		
Xylenes						X		X		
Phenol	X				X	X		X		
4-Methylphenol	X			X	X		X	X		
Dieldrin		X					X			
PCB-1254	X						X			
1,1,1-Trichloroethane			X					X		
Toluene			X				X	X		
1,2-Dichloroethene							X			
1,1-Dichloroethane			X					X	X	

000207

ORIGINAL (Red)

Table 6-13 (continued)

Summary of Indicator Chemicals at Dorney Road Landfill Site

Dorney Road RI

Chemical	Soil		Surface	Sediment	Subsurface Soil			Ground-	Residential	Seep
	On-site	Off-site	Water		On Waste	On Natural	Off-site	water	Wells	
INORGANICS										
Arsenic	X	X	X	X	X	X	X			X
Beryllium	X	X			X	X	X			
Cadmium	X	X			X	X	X			
Chromium	X	X	X		X	X	X			
Copper	X	X		X	X	X	X			X
Lead	X	X	X	X	X	X	X			X
Mercury	X	X		X	X	X	X			
Nickel	X	X		X	X	X	X			X
Zinc	X		X	X	X	X	X		X	X
Barium	X	X	X	X	X	X			X	X
Manganese			X	X	X	X	X		X	X
Thallium	X	X						X		

000208

- Certain chemicals were flagged with an "N" indicating there was presumptive evidence of this chemical at this concentration. If all reported concentrations of a particular chemical in all media were qualified with an N, this chemical was not considered further because of the tentative identification. However, if a chemical was definitely identified in some samples, then the sample in which it was presumptively identified also was included in the data base.

- Concentrations reported for duplicate samples from a given sampling point were first averaged by calculating a geometric mean of the sample and its duplicate. If this geometric mean was below the sample detection limit, the sample was treated as a nondetect.

- In evaluating risk, potentially carcinogenic polynuclear aromatic hydrocarbons (PAHs) are considered separately from noncarcinogenic PAHs. Therefore, data summary tables will list carcinogenic PAHs separately from noncarcinogenic PAHs. The carcinogenic PAHs evaluated were BaP, benz(a)anthracene, B(b,k)fluoranthene, B(k)fluoranthene, chrysene, dibenz(a,h)anthracene, and indeno(1,2,3-d)pyrene. The noncarcinogenic PAHs evaluated were anthracene, acenaphthene, acenaphthylene, B(ghi)perylene, fluoranthene, fluorene, phenanthrene, pyrene, dibenzofuran, and 2-methylphthalene.

- Some samples were flagged with an "R", indicating that the data are unusable because of quality control problems. The R flag indicates uncertainty in both the identity of the compound and its measured concentration. R-flagged values were not used in the risk assessment.

Based on these evaluations, approximately 60 chemicals were identified in one or more environmental media. Those chemicals most likely to contribute to risk are identified and selected for detailed evaluation according to specific guidelines. The guidelines used are as follows:

- If a chemical was detected in a single sample from an area and it was not detected in any other site-related sample from any medium, it was considered to have extremely low exposure potential and therefore was not selected for further evaluation in this assessment.

- Sample concentrations of inorganic chemicals were compared with those levels considered to be naturally occurring (background) to determine if the detected levels were evaluated above background. If an inorganic chemical was not detected in the background, it was selected for further evaluation, if the chemical met other guidelines.

- Chemicals for which ARARs or toxicity criteria (i.e. reference doses, allowable daily intakes, or cancer potency factors) have not been established cannot be assessed quantitatively and are therefore not carried through the quantitative assessment.

6.2.2 Selection of Indicator Chemicals

6.2.2.1 Soils

Soil samples were collected from 1) the on-site surface soil considered to be potentially contaminated and the off-site areas around the perimeter of the landfill, 2) either waste soil (soils within waste interval), natural soil (below the level of the waste) or off-site subsurface soil, and 3) an area off-site that was considered to be representative of background for the area (one sample).

Non-carcinogenic polynuclear aromatic hydrocarbons (PAHs) (with the exception of butylbenzyl phthalate, di-n-octyl phthalate, and 2-methyl phenol, 2-butanone, 2-hexanone, and 1,4-dichlorobenzene) were eliminated from further consideration in the quantitative assessment since no ARARs or toxicological criteria have been established for these compounds. Potassium, calcium, sodium, magnesium, and vanadium were eliminated from further consideration due to their low toxicities, which are not considered to be health hazards. Antimony was eliminated due to low frequency of detection in soil samples.

6.2.2.1.1 On-Site Surface Soil

Table 6-1 presents the frequency of detection, geometric mean, and maximum concentrations of chemicals detected in samples from the on-site area and also presents the background concentrations. In comparing concentrations of naturally occurring chemicals that have been detected in both site-related samples and background, statistical evaluation requires a minimum of three samples from each sample set. Because only one background surface soil sample was collected, statistical evaluation is not possible, and instead, maximum concentrations of chemicals in site-related samples were compared directly to the concentration of these same chemicals in the background sample. A chemical is considered to be elevated above background if the maximum concentration detected at the site exceeds the background level by more than an approximate factor of 2. A factor of 2 is believed to be conservative because background concentrations of some naturally occurring metals have been observed to vary over one order of magnitude.

As can be seen from Table 6-1, the metals arsenic, chromium, lead, copper, nickel and zinc, were detected in site-related samples at concentrations that exceeded background by a factor of 2 or more. Therefore, these chemicals are selected for further evaluation in the assessment of the covered landfill area. The detection limit for mercury in one background sample was greater than the concentration of mercury detected in a sample from the landfill, but mercury is selected as a chemical of potential concern because its true background concentration is not known. Non-carcinogenic polynuclear aromatic hydrocarbons (PAHs) (with the exception of naphthalene, 2-butanone, benzyl alcohol, 2,4-dimethylphenol, 4-methylphenol, and 2-methyl phenol) were eliminated from further consideration in the quantitative assessment since no ARARs or toxicological criteria have been established for these compounds.

6.2.2.1.2 Off-Site Surface Soil

The distribution of chemicals in soil samples collected from the unfilled off-site perimeter areas of the landfill is presented in Table 6-2 along with background concentrations. Levels of arsenic, chromium, copper, lead, and nickel were increased over background samples. All other inorganics, except mercury, were eliminated, because either the toxicity to humans is low, such as potassium and calcium, or their concentrations did not exceed background levels by a factor of two. Fewer organic chemicals were detected in off-site surface soil than in on-site surface soil. Among these, only bis(2-ethylhexyl)phthalate was elevated above background.

6.2.2.1.3 Subsurface Soil

Tables 6-3 to 6-5 summarize the concentrations of chemicals detected in subsurface samples collected from the waste soils, natural soils (below waste), and off-site areas. The chemicals present in subsurface soil are similar to those detected in surface soil. As with surface soil, noncarcinogenic PAHs, and other organics for which no toxicity data or ARARs are available are eliminated from further consideration. Levels of arsenic, chromium, copper, lead, nickel, zinc, barium and manganese were considerably elevated compared to background levels.

6.2.2.2. Groundwater

Groundwater monitoring wells were installed at and in the vicinity of the Dorney Road site to characterize groundwater both on-site and off-site. Groundwater samples were divided into on-site and off-site wells. Off-site samples were further divided into shallow and deep wells, based on well screening intervals. These subsets were selected because it may be possible to withdraw groundwater from the shallow portion of the water-table aquifer.

Tables 6-6 through 6-8 list the frequency of detection, concentration range, and geometric mean values of contaminants detected in groundwater monitoring wells installed on-site and off-site of the Dorney Road Landfill. The purpose of the groundwater sampling was to provide information regarding the degree and extent of groundwater contamination. Of the inorganics found in on-site groundwater samples, potassium, calcium, sodium, magnesium, thallium, and aluminum were eliminated from further consideration due to their low toxicities. Selenium was not found in any on-site groundwater samples.

6.2.2.3 Surface Water

Surface water samples were collected from the on-site water bodies at Dorney Road. A field blank surface water sample was collected. The surface water samples are considered to be representative of surface water quality at the site and will be representative of flow from the site. Table 6-9 presents the frequency of detection, geometric mean and maximum concentrations of chemicals detected in the on-site surface water and also presents background concentrations. As indicated in this table, the majority of the chemicals detected in surface water samples were inorganic metals that may be naturally occurring.

Of the surface water samples collected, all but acetone had a detection frequency of one in five. Of the inorganics, vanadium was eliminated from consideration since its concentration in surface water did not exceed twice the background concentration for this compound. Magnesium, calcium, aluminum, sodium, and potassium were eliminated from consideration due to their low toxicities.

6.2.2.4 Leachate Seeps and Sediments

Tables 6-10 and 6-11 list the frequency of detection, concentration range, and geometric mean values of contaminants in the leachate seep and sediment samples collected in the Dorney Road Landfill site. Leachate seeps are believed to be release points for groundwater.

Each of the organic chemicals detected in leachate seep samples was present in only one of the two sites tested. Of the inorganics, barium and vanadium were eliminated from consideration as inorganic contaminants of potential concern since their concentration in leachate seeps did not exceed twice the background concentration for each compound. Potassium, calcium, sodium, magnesium, and aluminum were eliminated from further consideration due to their low toxicities, which are not considered to be health hazards.

Sediment samples were collected along with surface water samples from on-site surface water areas. Concentrations of chemicals detected in sediment samples, as well as background, are summarized in Table 6-10. Because only one background sediment sample was collected, the same rule was applied for determining whether chemical concentrations were site-related; a factor of 2 was used. As indicated in Table 6-10, all inorganic chemicals that were detected in the background sample were present at concentrations in site-related samples that exceeded background by more than a factor of 2. Even though many of the inorganic chemicals were not detected in background, a comparison of the background detection limits to the maximum concentrations indicated that the concentrations generally are elevated above the background detection limits. Although the concentration of mercury was qualified with an N (presumptive evidence), it is considered further because it was positively detected in soil and in a shallow groundwater sample. All of the other inorganic chemicals are selected for further evaluation in this assessment with the exception of thallium which was detected in only one sample and infrequently in other media. Because none of the organic chemicals detected in samples from this area were detected in the background sample, they are selected as chemicals of potential concern, except for those without toxicity data, such as 2-methylphenol or benzoic acid.

Of the sediment samples collected, all but acetone had a detection frequency of one in five. Calcium, magnesium, and aluminum were eliminated from further consideration due to their low toxicities, which are not considered to be health hazards. Cobalt, thallium, nickel, mercury, chromium, beryllium were eliminated from consideration as inorganic contaminants of potential concern since their concentrations in sediments did not exceed twice the background concentration for each compound.

6.2.2.5 Residential Water

Seven residential wells in the vicinity of the Dorney Road Landfill site were selected during the initial site reconnaissance. All organic chemicals identified in the residential water samples were retained for further consideration as contaminants of potential concern. Of the inorganics, vanadium and iron were dismissed from further consideration since their concentrations in residential water did not exceed twice the background concentration for each compound. Magnesium, calcium, sodium, and potassium were eliminated due to their low toxicities.

Results of environmental sampling have been discussed in detail in the RI report. These results are summarized briefly here for the purpose of identifying chemicals that are associated with the site and that will be considered for evaluation in this endangerment assessment.

6.2.2.6 Summary

A summary of the indicator chemicals found in the various environmental media are listed in Table 6-13.

6.3 HUMAN EXPOSURE ASSESSMENT

This section addresses the potential pathways by which populations could be exposed to contaminants at or originating from the Dorney Road site. Potential exposure pathways are identified under both current and likely future land use of the site and surrounding area.

An important step in identifying exposure pathways is to consider the mechanisms by which the chemicals of potential concern at the site may migrate in the environment. These migration pathways are discussed in Section 6.3.1, followed in Section 6.3.2 with a discussion of potential exposure scenarios and a determination of the exposures that will be evaluated in this assessment.

6.3.1 Migration Potential

An evaluation of the environmental fate and transport of the site-related chemicals present at and in the vicinity of the Dorney Road site is important in determining the potential for migration of the contaminants and in assessing the potential for exposure to the contaminants. The migration of contaminants, that in the past have been and in the future may be released from the landfilled materials at this site, may be significantly influenced by environmental factors, such as the hydrogeological characteristics of the site and surrounding area, as well as the physical/chemical characteristics of the chemicals of potential concern at the site.

6.3.1.1 Site Environmental Factors

The Dorney Road Landfill site is underlain by the Allentown Formation which is described as a light to dark gray predominantly dolomitic carbonate with minor limestone, shaly limestone, shale and cherty units. Overlying the bedrock is a residual soil (Washington silt-loam) which is highly variable in thickness and composed primarily of silts and clays. Soils vary in depth from zero to 90 feet (based on refraction survey) within the investigation area but average approximately 30 feet in thickness.

The aquifers associated with the Dorney Road Site are comprised of a shallow perched system within the waste disposal area and an unconfined water-table aquifer. Based on available data the perched system appears to be contained within the waste. Although minor localized saturated zones may be encountered outside the landfill, it is not clear if these saturated zones are connected to the landfill system.

Groundwater flow within the water-table aquifer is south-southeast. Flow directions and velocities are controlled by fracture orientation, fracture density and the degree of weathering the bedrock has undergone. Flow velocities and hydraulic conductivities vary by more than an order of magnitude from north to south as indicated by the pump test data obtained during this investigation. A detailed description of the site geology and hydrogeology is provided in Sections 4.2. and 4.3.

6.3.1.2 Characteristics of Potential Sources of Contamination

The majority of the waste disposed of in the Dorney Road Landfill was reported to have been municipal waste. The site was an open dump prior to 1966 with waste disposal in an abandoned iron mine.

As discussed in Section 6.2, many inorganic and organic chemicals have been detected, albeit at generally low levels, in the various media sampled. The distribution of these chemicals is variable. However, general inorganic chemicals, such as barium, zinc, arsenic and mercury have been found to be widespread in most media sampled. Carcinogenic PAHs were found in on-site surface and off-site subsurface soils.

6.3.1.3 Mechanisms of Migration

Although a complete characterization of the landfill wastes has not been performed, results of the environmental sampling of media likely to be affected by the landfill indicate that many natural and man-made chemicals are present in the landfill waste. Because the wastes were a mixture, different chemicals are likely to have been released from different areas. In this section, the mechanisms of migration of site-related chemicals will be discussed generally.

ORIGINAL (Red)

6.3.1.4 General Migration Processes

The general processes by which chemicals in the landfill can migrate at the site include:

- leaching from waste/soils into groundwater,
- transport in groundwater,
- volatilization from waste/soils, leachate seeps, surface water, and
- surface runoff during storm events. These processes are briefly discussed below.

Chemicals will be released from the landfilled materials in the form of leachate. In unsaturated areas of the landfill, leachate generated as a result of infiltrating rainwater will percolate through the waste and soil into the groundwater. Organic chemicals having high organic carbon partition coefficients (e.g., PAHs, PCBs, phthalates, and pentachlorophenol under acid conditions) will tend to adsorb to organic matter in waste and soils and their migration into the groundwater will be retarded. The other organic chemicals detected in soil (e.g., chloroform and toluene) will tend to migrate more freely into groundwater and be transported in the groundwater. These organic chemicals are among the organic chemicals that have been detected in groundwater samples. The extent to which inorganic chemicals will be mobile in leachate and groundwater is more complicated and is dependent on several factors including pH, oxidation-reduction potential, the presence of other anions or cations, and the environmental medium in which the inorganic chemical is present. The degree of partitioning of inorganic chemicals between soil and water is described by their soil-water distribution coefficient (K_d). Based on their high K_d's, aluminum, chromium (III), lead, and vanadium are the potentially site-related inorganic chemicals that will be the least mobile in the groundwater.

With respect the migration of contaminants into air, contaminants in the form of vapors or dusts would have been emitted from the wastes into the air during operation of the landfill. Currently, however, because the surface of the wastes in the landfill area are generally covered with clean soils and because the landfill is partially vegetated, significant quantities of contaminated dusts are unlikely to be generated. With respect to gases and vapors, it is likely that significant amounts of landfill gas are being generated. However, release of gases, produced by the anaerobic degradation of organic materials in the presence of moisture, can also potentiate the transport of other volatiles. However, available soil samples in the landfill area show very low levels of potentially more toxic volatile chemicals. With respect to volatization from surface waters, the volatile chemicals detected in surface waters (phenol and acetone) were at low concentrations; therefore, the emission of significant concentrations of vapors from the surface waters is not expected.

ORIGINAL
(Red)

Contaminants in surface soil could be transported during storm events in surface water runoff or soil erosion into the on-site ponds or marsh areas. Surface water runoff occurs by way of two riprap channels. This may be a transport mechanism through which site-related chemicals are transported into the off-site surface water.

6.3.2 Potentially Exposed Populations and Exposure Pathways

An exposure pathway (the link between the source and the receptors) is defined by the following four elements:

- A source and mechanism of chemical release to the environment;

- An environmental transport medium for the released chemical;

- A point of potential exposure by the receptor with the medium; and

- A route of exposure (i.e., inhalation, ingestion, dermal contact).

An exposure pathway is considered "complete" if all these elements are present. The first two elements of an exposure pathway, a source and transport of a chemical, have been addressed above and in previous sections of this report. This section addresses the last two elements and identifies populations exposed to site-related contaminants both on-site and off-site under current and possible future land-use conditions and also identifies the routes through which these populations may be exposed.

The Dorney Road site is located on the southwest boundary of Upper Macungie Township in Lehigh County, Pennsylvania, approximately eight miles southwest of Allentown. The site covers approximately 27 acres of documented landfill area which is bounded to the east by Dorney Road and extends westward such that the southwest corner of the site is in Longswamp Township, Berks County. The major portion of the Dorney Road site consists of a landfill surrounded by a soil berm.

The area is zoned for agricultural use and the site is completely surrounded by cultivated farmland where feed corn is grown for dairy and beef cattle, with residential areas and farms bordering on the site. The site is used mainly as a recreational area and can be accessed easily by foot. It is a waterfowl habitat and is frequented by hunters. Several man-made ponds are located on the site which can be easily accessed.

Taking into account the above factors, potential pathways of exposure to contaminants originating at the Dorney Road site under current land-use conditions have been identified and are discussed below by exposure medium (soil, sediment, seep, groundwater, and surface water) for on- and off-site where applicable. Future land-use conditions are also discussed for soil and groundwater. These potential exposure pathways are also summarized in Tables 6-14 and 6-15 along with an indication of whether the pathway is complete and to what degree the potential for substantial exposure exists.

Table 6-14

Potential Pathways of Exposure to Contaminants Originating at the Dorney Road Site Under Current-Use Conditions

Dorney Road RI

Exposure Medium	Potential Routes of Exposure	Potential Receptors	Pathway Complete?	Potential for Significant Exposure
Soil (on-site)	Dermal absorption, incidental ingestion	Recreational users	Yes. Site is water fowl habitat that is leased for hunting purposes.	High. Surface soils are highly contaminated.
Soil (off-site)	Dermal absorption, incidental ingestion	Gardeners and farmers	Yes. Area is used for agricultural purposes.	Minimal. Levels of contaminants off-site are low.
Air (on-site)	Inhalation of volatile contaminants from soil or surface water and/or fugitive dust.	Recreational users	No. Volatilization from soil and surface water is unlikely. On-site area is marshy and covered with sparse vegetation. Inhalation of dust is not expected.	Negligible.
Groundwater (on-site)	Dermal absorption, inhalation, ingestion	Recreational users	No. Groundwater on-site is not currently used for any purpose.	None.
Groundwater (off-site)	Inhalation, ingestion	Residential users	Yes. Residential wells show that there are measurable levels of contaminants.	Moderate.
Surface water (on-site)	Dermal absorption, incidental ingestion	Recreational users	Yes. While persons are hunting, contact with surface water is likely.	Low.
(fishing)	Ingestion	Recreational users	No. There are no fishing activities reported on site.	None.
(swimming)	Dermal absorption, incidental ingestion	Recreational users	No. There are no swimming activities reported on site.	None.
Sediments and seeps	Dermal absorption	Recreational users	Yes. While persons are hiking or hunting, contact with sediments and seeps is possible.	Low.

ORIGINAL (Red)

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Table 6-15

Potential Pathways of Exposure to Contaminants Originating at the Dorney Road Site Under Future-Use Conditions

Dorney Road RI

Exposure Medium	Potential Routes of Exposure	Potential Receptors	Pathway Complete?	Potential for Significant Exposure
Soil (on-site)	Dermal absorption, incidental ingestion	Residential users	Yes. In the future, if the site is used for residences, children at play and adults gardening could contact soils.	High
Groundwater (on-site)	Ingestion, inhalation	Residential users	Yes. Groundwater may be utilized as drinking water.	High
Surface soil (on-site)	Dermal absorption, incidental ingestion	Workers	Yes. In the future, if site is developed into a residential or industrial area.	High
Subsurface soil (on-site)	Dermal absorption, incidental ingestion	Workers	Yes. In the future, if site is developed into a residential or industrial area.	High

ORIGINAL (Red)

Exposure to surface soil on-site may occur through direct contact with surface soil by teenagers or adults who engage in outdoor hunting activities. Routes of exposure to be considered are incidental ingestion of soil and, for appropriate organic chemicals, dermal absorption. The Dorney Road site is largely a marsh-type area, with the soil covering most of the site being damp and partially covered with vegetation. Based on this fact, very little inhalation exposure of contaminated dusts should occur, therefore no inhalation scenarios were developed for on-site soil. The use of land off-site for agricultural uses may result in dermal, ingestion or inhalation absorption of surface soils through plowing and gardening of the soil. However, given the concentrations in the on-site soil versus off-site soil, exposure to off-site surface or subsurface soil is not expected to result in a significant exposure to the chemicals being evaluated and, therefore, this exposure scenario was not evaluated. Future assessments of on-site and surface and subsurface soil were based on the development of the landfill site into a residential area. Recreational areas such as playgrounds or baseball fields could be developed resulting in dermal, inhalation or incidental ingestion of surface soils by children, teenagers and adults.

Given the fact that the Dorney Road site has several ponds and consists mainly of a marshy-type soil, numerous locations are available for exposure to surface water. Assessments were made for adults and teenagers exposed to surface water through outdoor hunting activities. Dermal absorption of surface water contaminants would result following activities, such as boating, or wading into the water while duck hunting. A minor incidental ingestion pathway is also considered. Given the nature of the site, no swimming or fishing is expected to occur.

In conjunction with exposure to surface water, exposure to contaminated sediment may occur when surface water is disturbed. Sediment was assumed to accumulate on hands, lower legs or exposed neck, while hunting in or near surface water. Since sediment would be a thick muddy-type soil, no inhalational exposure was assumed and incidental ingestion would be minimal.

Leachate seeps are located on the Dorney Road site. It was assumed that these seeps crossed at least two pathways of access into the site. Dermal exposure of contaminants could occur if seeps were crossed on foot to achieve access to the site. Maximum dermal exposure from seep contaminants was assumed if seeps were crossed to enter the site as well as exit.

On-site groundwater is not currently used as a potable water supply or for other purposes, such as irrigation; therefore, exposure to on-site groundwater was not assumed. Exposure to groundwater contaminants is presently assumed to occur through off-site residential wells. Ingestion and inhalation exposure to groundwater contaminants is expected to occur through daily showering and intake of drinking water. In the future, assuming the site to be developed into a residential area, inhalation and ingestion exposure to on-site groundwater contaminants would also be assumed to occur through daily showering and drinking water.

Ambient air levels of contaminants resulting from contaminated dusts or landfill gases on-site were reported to be below acceptable levels. Therefore, no assessments of this exposure medium were addressed.

In addition to present and future risk assessments, soil and groundwater clean-up concentrations were derived. These concentrations, based on specific exposure scenarios, address what soil concentrations would need to be achieved to pose a minimal threat to residents in the Dorney Road site area from exposure in the future to soil or groundwater.

6.4 HUMAN RISK CHARACTERIZATION

According to guidelines for preparing risk assessment as part of the RI/FS process (EPA, 1986a), the potential adverse effects on human health should be assessed where possible by comparing chemical concentrations found in environmental media at or near the site with applicable or relevant and appropriate requirements (ARARs) or other guidance that has been developed for the protection of human health or the environment. If ARARs are available for all chemicals in all environmental media, then a comparison to ARARs constitutes the risk assessment. If not, quantitative risk estimates must be developed in addition to the comparison to available ARARs. Suitable ARARs or other guidance are available only for some site-related chemicals in groundwater and surface water. Therefore, in addition to a comparison with ARARs, quantitative risk estimates were derived for all human exposure pathways.

6.4.1 Comparison with Applicable or Relevant and Appropriate Requirements (ARARs)

The EPA's Interim Guidance on ARARs (EPA, 1987a) defines ARARs as follows:

> Applicable requirements means those cleanup standards, standards of control, and other substantive environmental protection requirements, criteria, or limitations promulgated under Federal or State law that specifically address a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance at a CERCLA site.
>
> "Applicability" implies that the remedial action or the circumstances at the site satisfy all of the jurisdictional prerequisites of a requirement . . .

ORIGINAL (Red)

> __Relevant and appropriate requirements__ means those cleanup standards, standards of control, and other substantive environmental protection requirements, criteria, or limitations promulgated under Federal or State law that, while not "applicable" to a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance at a CERCLA site, address problems or situations sufficiently similar to those encountered at the CERCLA site that their use is well suited to the particular site.
>
> The relevance and appropriateness of a requirement can be judged by comparing a number of factors, including the characteristics of the remedial action, the hazardous substances in question, or the physical circumstances of the site, with those addressed in the requirement. It is also helpful to look at the objective and origin of the requirement. For example, while RCRA regulations are not applicable to closing undisturbed hazardous waste in place, the RCRA regulation for closure by capping may be deemed relevant and appropriate.
>
> A requirement that is judged to be relevant and appropriate must be complied with to the same degree as if it were applicable. However, there is more discretion in this determination: it is possible for only __part__ of a requirement to be considered relevant and appropriate, the rest being dismissed if judged not to be relevant and appropriate in a given case.
>
> Non-promulgated advisories or guidance documents issued by Federal or State governments do not have the status of potential ARARs. However, . . . they may be considered in determining the necessary level of cleanup for protection of health or environment.

Only those ARARs or advisories or guidance that are ambient or chemical-specific requirements [i.e., those requirement which "set health or risk-based concentration limits or ranges in various environmental media for specific hazardous substances, pollutants, or contaminants" (EPA, 1987a)], as opposed to ARARs which are classified as action-specific or locational requirements, are used in this risk assessment.

No Federal, State, or County standards, criteria, or guidelines have been identified for chemicals in soil. EPA has, however, issued guidance on the use of water standards as chemical-specific ARARs (52 FR 32496-32499). This guidance is used as the basis for the comparisons to predicted groundwater and surface water concentrations for the Dorney Road Landfill site presented in this section of the Endangerment Assessment.

Two kinds of water standards are currently used with which compliance is potentially required: Maximum Contaminant Levels (MCLs), Federal Ambient Water Quality Criteria (FAWQC).

Table 6-16 lists ARARs for chemicals of potential concern at the Dorney Road site and the concentrations of these chemicals in the residential wells, surface water, and groundwater. As the table indicates, the ARARs for several chemicals are exceeded. In the groundwater, the maximum concentration of arsenic, barium, cadmium, chromium, manganese, lead, benzene, and vinyl chloride exceed the ARARs. The geometric mean concentrations of vinyl chloride and benzene also exceed the ARARs. In residential well water only the maximum concentration of trichloroethylene exceeded the ARAR, while in surface water all chemicals detected were below their corresponding ARARs. ARARs have not yet been established for all chemicals detected in the various water media on- and off-site at the Dorney Road Landfill.

6.4.2 Health Effects Classification and Criteria Development

For risk assessment purposes, individual pollutants are separated into two categories of chemical toxicity depending on whether they exhibit noncarcinogenic or carcinogenic effects. This distinction relates to the currently held scientific opinion that the mechanism of action for each category is different. For the purpose of assessing risks associated with potential carcinogens, EPA has adopted the scientific position that a small number of molecular events can cause changes in a single cell or a small number of cells that can lead to tumor formation. This is described as a no-threshold mechanism because there is essentially no level of exposure (i.e., a threshold) to a carcinogen that will not result in some finite possibility of causing the disease. In the case of chemicals exhibiting noncarcinogenic effects, however, it is believed that organisms have protective mechanisms that must be overcome before the toxic endpoint is manifested. For example, if a large number of cells performs the same or similar functions, it would be necessary for significant damage or depletion of these cells to occur before an effect could be seen. This threshold view holds that a range of exposures from just above zero to some finite value can be tolerated by the organism without appreciable risk of causing the disease (EPA, 1987b).

6.4.2.1 Health Effects Criteria for Noncarcinogens

Health criteria for chemicals exhibiting noncarcinogenic effects are generally developed using risk reference doses (RfDs) developed by the EPA RfD Work Group or RfDs obtained from Health Effects Assessments (HEAs) or from the Office of Drinking Water analysis in support of health-based drinking water standards. The RfD, expressed in units of mg/kg/day, is an estimate of the chronic daily exposure to the human population (including sensitive subpopulations) that is likely to be without an appreciable risk of adverse effects. RfDs usually are derived from human studies involving workplace exposures or from animal studies and are adjusted using uncertainty factors. The RfD provides a benchmark to which chemical intakes by other routes (e.g., via exposure to contaminated environmental media) may be compared.

ORIGINAL (Red)

Table 6-16

Comparison of Water Concentrations with Applicable or Relevant and Appropriate Standards Established by the EPA (1986a)

Dorney Road RI

Chemical	ARARs (ug/l)		Residential Water (ug/l)		Groundwater (On-site) (ug/l)		Surface Water (ug/l)	
	MCL	MCLG	Mean[a]	Maximum	Mean[a]	Maximum	Mean[a]	Maximum
ORGANICS								
Benzene	5[b]	---	---	---	5.16	14	---	---
Bis(2-ethylhexyl)-phthalate	---	---	NA	2	13.80	40	---	---
1,1-dichloroethane	---	---	NA	2	---	---	NA	9
1,2-dichloroethylene	---	70[b]	---	---	11.59	79	---	---
Diethyl phthalate	---	---	---	---	8.43	20	---	---
Ethylbenzene	---	680[b]	---	---	107.9	160	NA	3
Styrene	---	140[b]	---	---	NA	43	---	---
Tetrachloroethylene	---	---	---	---	NA	1	---	---
Toluene	---	2000[b]	---	---	160.6	740	NA	8
Trichloroethylene	5[b]	---	NA	9	---	---	---	---
Vinyl Chloride	1[b]	---	---	---	6.23	25	---	---
Xylenes	---	440[b]	---	---	305.70	530	---	---
INORGANICS								
Arsenic	50	---	---	---	12.9	140	NA	1.7
Barium	1000	---	13.30	31	767.7	3480	71.8	580
Beryllium	---	---	---	---	4.6	22	---	---
Cadmium	10	---	---	---	5.8	19	---	---
Chromium	50	---	---	---	38.0	72	6.5	9.95
Copper	---	1300[b]	---	---	50.7	218	---	---
Lead	50	---	---	---	627.1	11900	8.8	30
Manganese	---	---	6.50	83	11080.0	420000	1083.0	31000
Mercury	2	---	---	---	0.27	0.64	---	---
Nickel[c]	---	---	---	---	684	3540	---	---
Zinc	---	---	26.43	448	4165	37700	19.1	34

[a] Geometric mean.
[b] EPA proposed MCLs and MCLGs (EPA, 1986a).
[c] Neither adopted nor proposed MCL or MCLGs were available; however, the EPA Drinking Water Health Advisory for Nickel in a 70 kg human, exposed over a lifetime is 350 ug/l.

NA = not applicable. Only detected in one sample, and use of one-half of the detection limit in calculating the mean results in a mean concentration that is less than the detection limit.

6.4.2.2 Health Effects Criteria for Potential Carcinogens

Cancer potency factors, developed by EPA's Carcinogen Assessment Group (CAG) for potentially carcinogenic chemicals are derived from the results of human epidemiological studies or chronic animal bioassays. Potency factors are expressed in units of $(mg/kg/day)^{-1}$. The animal studies on which some potency factors are based must usually be conducted using relatively high doses to detect possible adverse effects. Because humans are expected to be exposed at lower doses than those used in the animal studies, the data are adjusted by using mathematical models. The data from animal studies are fitted to the linearized multistage model to obtain a dose-response curve. The low-dose slope of the dose-response curve is subjected to various adjustments, and an interspecies scaling factor is applied to derive the cancer potency factor for humans. Dose-response data derived from human epidemiological studies are fitted to dose-time-response curves on an individual basis.

EPA assigns weight-of-evidence classifications to potential carcinogens. Under this system, chemicals are classified as either Group A, Group B1, Group B2, Group C, Group D, or Group E. Group A chemicals (human carcinogens) are agents for which there is sufficient evidence to support the causal association between exposure to the agents and cancer in humans. Groups B1 and B2 chemicals (probable human carcinogens) are agents for which there is limited (B1) or inadequate (B2) evidence of carcinogenicity from human studies but for which there is sufficient evidence of carcinogenicity from animal studies. Group C chemicals (possible human carcinogens) are agents for which there is limited evidence of carcinogenicity in animals, and Group D chemicals (not classified as to human carcinogenicity) are agents with inadequate human and animal evidence of carcinogenicity or for which no data are available. Group E chemicals (evidence of non-carcinogenicity in humans) are agents for which there is not evidence of carcinogenicity in human or animal studies.

The cancer potency factor is used to estimate the excess lifetime carcinogenic risk associated with low-dose exposure to a potential carcinogen. Cancer potency factors derived from animal studies using the linearized multistage model typically provide 95% upper-bound estimates of excess lifetime cancer risks. Whereas the actual risks are unlikely to be higher than those estimated risks, they could be considerably lower. Cancer potency factors derived from low-dose human epidemiological studies are typically intended to provide best estimates of lifetime cancer risk but may, in fact, underestimate actual risk.

6.4.3 Health Effects Criteria for Use in Risk Evaluation

Table 6-17 presents the health effects criteria that will be used to evaluate potential health risks posed by noncarcinogens and carcinogens in surface water, groundwater, residential well water, and soils. No inhalation criteria are presented, because the potential for inhalation exposure (to contaminated dust and volatilized chemicals at or near the site) is considered to be very low. No human health effects criteria are available for calcium, iron, magnesium, potassium, sodium, benzylbutylphthalate, and noncarcinogenic PAHs, and therefore these chemicals will not be evaluated.

Table 6-17

Health Effects Criteria for Chemicals in the Surface Water, Soil, Groundwater, Sediment, and Leachate Seep at the Dorney Road Site

(Ingestion/Dermal Absorption)

Dorney Road RI

Chemical	Source of RfD	Reference Dose (RfD) (mg/kg/day)	Cancer Potency Factor (mg/kg/day)	Weight of Evidence[a]
ORGANICS				
Benzene		---	5.20E-02	A
Bis(2-ethylhexyl) phthalate	IRIS	2.00E-02	$8.30\text{x}10^{-3}$	B2
Chlorobenzene	HEA	2.70E-02	---	
Chloroform	IRIS	1.00E-02	8.10E-02	B2
1,1-dichloroethane		---	9.00E-02	
1,2-dichloroethylene		---	5.80E-01	
Di-N-butylphthalate		1.00E-01	---	
Dieldrin		---	3.00E+01	
Diethylphthalate	IRIS	8.00E-01	---	
Ethylbenzene	IRIS	1.00E-01	---	
4-methyl-2-pentanone	IRIS	5.00E-02	---	
4-methylphenol	HEA	5.00E-02	---	
Naphthalene		4.10E-02	---	
PAHs, carcinogenic[b]		---	1.15E+01*	---
PCBs		---	7.00E+00	
Phenol	IRIS	4.00E-02	---	
Styrene	IRIS	2.00E-02	---	
Tetrachloroethylene	IRIS	---	5.10E-02*	B2
Toluene	IRIS	3.00E-01	---	
1,1,1-trichloroethane	IRIS	9.00E-02	---	
Trichloroethylene		---	1.10E-02	B2
Vinyl Chloride		---	2.30E+00	A
Xylenes(mixed)	IRIS	2.00E+00	---	

Table 6-17 (continued)

Health Effects Criteria for Chemicals in the Surface Water, Soil, Groundwater, Sediment, and Leachate Seep at the Dorney Road Site (Ingestion/Dermal Absorption)

Dorney Road RI

Chemical	Source of RfD	Reference Dose (RfD) (mg/kg/day)	Cancer Potency Factor (mg/kg/day)	Weight of Evidence[a]
INORGANICS				
Arsenic		---	1.50E+00	A
Barium	IRIS	5.00E-02	---	
Beryllium	IRIS	5.00E-03	---	B1
Cadmium	MCLG	5.00E-04	---	
Chromium VI	IRIS	5.00E-03	---	
Copper	HEA	3.70E-02	---	
Lead	EPA	6.00E-04	---	
Manganese	HEA	2.20E-01	---	
Mercury	EPA	1.40E-03	---	
Nickel	IRIS	2.00E-02	---	A
Thallium		4.00E-04	---	
Zinc	HEA	2.10E-01	---	

[a]EPA carcinogenic weight-of-evidence classification. See text for description of categories.

[b]For the purpose of the risk assessment, all carcinogenic PAHs are assumed to be as toxic as B(a)P.

*Currently under review.

--- No criterion developed for this chemical and this type of toxicity.

ORIGINAL (Red)

6.4.4. Quantitative Risk Characterization

As noted above, a more quantitative risk characterization must be completed because ARARs are not available for all of the chemicals in each environmental medium under consideration. Therefore, a quantitative risk characterization is performed for all complete exposure pathways at the Dorney Road site. To quantitatively assess the risks to human health associated with the current-use and future-use exposure scenarios considered in this assessment, the exposure point concentrations presented in Section 6.2 are converted to chronic daily intakes (CDIs). CDIs are expressed as the amount of a substance taken into the body per unit body weight per unit time, or mg/kg/day. A CDI is averaged over a lifetime for carcinogens (EPA, 1986b) and over the exposure period for noncarcinogens (EPA, 1986c). CDIs are calculated separately for each exposure pathway because different populations may be affected by individual pathways.

For potential carcinogens, excess lifetime cancer risks are obtained by multiplying the daily intake of the contaminant under consideration by its cancer potency factor. This is appropriate for cancer risks of 10^{-2} (i.e., one excess cancer in every 100 individuals exposed throughout their lifetime) or less. A risk level of 10^{-6} representing an upperbound probability that one excess cancer case in 1,000,000 individuals might result from exposure to the potential carcinogen, is often used as a benchmark by regulatory agencies. Accordingly, 10^{-6} will be the target risk level used in this report. It should be noted that, in general, EPA cancer potency factors based on animal data (e.g., PAHs) are 95% upper confidence limit values based on the linearized multistage model. Thus, the actual risks associated with exposure to a potential carcinogen, when compared to risks derived from animal data, are not likely to exceed the risks estimated using these cancer potency factors, but may be lower. EPA cancer potencies based on human data (e.g., arsenic) are point estimates based on a linear absolute risk model. In its Health Assessment Document for Arsenic (EPA, 1984), the Agency notes that "while it is unlikely that the true risks would be higher than these estimates, they could be substantially lower."

Potential risks are presented for noncarcinogens as the ratio of the chronic daily intake exposure to the reference dose (CDI:RfD). The sum of all of the ratios of chemicals under consideration is called the hazard index. The hazard index is useful as a reference point for gauging the potential effects of environmental exposures to complex mixtures. In general, hazard indices that are less than 1 are not likely to be associated with any health risks and are therefore less likely to be of regulatory concern than hazard indices greater than 1. A conclusion should not be categorically drawn, however, that all hazard indices less than 1 are "acceptable." This is a consequence of the perhaps one-order-of-magnitude or greater uncertainty inherent in estimates of the RfD and CDI, in addition to the fact that the individual terms in the hazard index calculation are added, which contributes to the uncertainty.

In accordance with EPA's guidelines for evaluating the potential toxicity of complex mixtures (EPA, 1986d), it was assumed that the toxic effects of the contaminants of concern would be additive. Thus, lifetime excess cancer risks and the CDI:RfD ratios were summed to indicate the potential risks associated with mixtures of potential carcinogens and noncarcinogens, respectively. In the absence of specific information on the toxicity of the mixture to be assessed or on similar mixtures, EPA guidelines generally recommend assuming that the effects of different components on the mixtures are additive when affecting a particular organ or system. Synergistic or antagonistic interactions may be taken into account if there is specific information on particular combinations of chemicals. In this risk assessment, it was assumed that the effects of the contaminants of concern were additive.

In this section of the risk assessment, the intakes of chemicals of concern by potentially exposed populations are first calculated. To determine these intakes, assumptions are made concerning chemical concentrations, exposed populations, and exposure conditions such as frequency and duration of exposure. For each exposure scenario evaluated, two exposure cases, an average case and maximum plausible case, are considered. For the average exposure case, geometric mean concentrations are used together with what are considered to be the most likely (although conservative) or average exposure conditions. For the maximum plausible case, the highest measured concentrations are used together with high estimates of the range of potential exposure parameters relating to the frequency/duration of exposure and quantity of contaminated media contacted. It should be noted that the exposure scenarios assumed for the maximum plausible case, while considered possible, are likely to apply, if at all, to only a very small segment of the potentially exposed populations.

Chronic daily intakes, excess lifetime cancer risks, and CDI:RfD ratios for the site-related chemicals considered in this assessment, as well as the assumptions and procedures used to calculate these values, are shown for the scenarios evaluated in the subsections that follow.

6.4.4.1 Estimates of Exposure and Assessment of Risks Under Current- Use Conditions

Direct Contact with On-Site Surface Soil by Teenagers and Adults

Direct contact with soil is considered under both current-use and future-use scenarios. Under the current-use scenario exposure is assumed to occur on-site in areas of the site that are currently used for recreational activities. As described previously, the site has several marsh areas that serve as a water fowl habitat, and as such, is leased for hunting purposes. It is expected that both teenagers (ages 14-18) and adults would hunt in the area. Exposure is expected to occur by both dermal absorption of chemicals to exposed skin and by incidental ingestion of soil. Average and maximum plausible cases are considered, based on geometric mean and maximum concentrations detected in surface soil.

ORIGINAL (Red)

It is assumed that teenagers and adults will go hunting (on the average) once a month, while under the maximum plausible case, it is assumed that both will hunt (on the average) once a week. The frequency of this activity will vary seasonally and be dependent on the length of the specific hunting season and the prevailing weather conditions. The assumed years of exposure for the teenager is five, while exposure is assumed to occur throughout adult life, from ages 18 to 70. Assumptions for this pathway are presented in Table 6-18.

For the dermal pathway, exposure will also vary with their dermal contact rate. The exposure rates were based on a range of potential soil contact rates (0.5-1.5 mg soil/cm^2) from Schaum (1984) multiplied by a range of exposed body surface area estimates from EPA (1985b). For the average case teenager, the 50th percentile total body surface/area estimates were multiplied by the fraction of the total body area comprising the hands. For the maximum plausible case, the 95th percentile total body surface area estimates were multiplied by the fraction of the total body area comprising the hands and arms. Exposure rates for those 19 years and older were based on mean surface areas by body part for adults averaged across sexes. The exposed surface areas for the average and maximum plausible cases were assumed to be the hands and forearms, and the hands, forearms and lower legs, respectively.

For dermal absorption of contaminants from soil, an additional set of exposure parameters on skin absorption is required. All of the organic compounds of concern present in soil at the Dorney Road site can be absorbed through the skin to some extent. However, this route of exposure has not been well studied and is difficult to quantify. According to McLaughlin (1984), most volatile compounds would fall in the category of approximately 10% dermal absorption. More refined information exists for the PAHs and the Drinking Water Criteria for PAHs (EPA, 1986d) suggests an average dermal absorption of 0.2% and a maximum of 2%. Wester et al. (1987) recommend a value of 7% for dermal absorption of PCBs. Depending on the types and concentrations of chemicals present in soil, the strength with which individual chemicals adsorb to soil particles and the extent to which they move through the skin exposure may vary considerably. However, in this assessment, a value of 10% will be used as a conservative approximation of the average and maximum dermal absorption rates for the organic chemicals of concern. A value of 0.2% will be used to approximate the average dermal adsorption rate for PAHs, while a value of 2% will be used to approximate the maximum dermal absorption. A value of 7% will be used to approximate dermal absorption, both average and maximum, for PCBs.

Significant exposure via dermal exposure of the inorganic chemicals of potential concern is not expected because of the very low permeability of skin to metal ions (Schaeffer et al., 1983).

ORIGINAL

Table 6-18

Assumptions for Use in the Exposure Assessment for Direct Contact with Soil by Teenagers and Adults at the Dorney Road Site

Dorney Road RI

(Current-Use Scenario)

Parameter	Teenager		Adult	
	Average	Plausible	Average	Plausible
Age of people exposed	14-18	14-18	19+	19+
Frequency of exposure (E)	12	52	12	52
Duration of exposure (YR)	5	5	51	51
Average body weight over period of exposure (BW)	55	55	70	70
Incidental ingestion of contaminated soil (I)	50	100	50	100
Percent of PCBs and PAHs absorbed from ingested soil (AI)	15%	45%	15%	45%
Percent of non-PAH compounds absorbed from ingested soil (AI)	100%	100%	100%	100%
Soil contact rate for use in dermal adsorption estimate (CD)	0.43	5.68	1.45	5.80
Percent of organic compound absorbed dermally from skin (ABS)				
- PAHs	0.2%	2%	0.2%	2%
- PCBs	7%	7%	7%	7%
- Other organic compounds	10%	10%	10%	10%
Percent of inorganic compound absorbed dermally from skin	negligible	negligible	negligible	negligible
Lifetime (carcinogens) (YL)	70	70	70	70
Period of exposure (noncarcinogens) (YL)	5	5	51	51

ORIGINAL (Red)

Table 6-18 presents the assumptions for incidental soil ingestion and oral absorption factors for chemicals sorbed to soil. These factors assume that PCBs and PAHs are strongly sorbed to soil, and consequently may be less bioavailable than these same chemicals in drinking water or food (typical media used in animals studies used to derive toxicity criteria). An absorption factor of 0.15 is used for the average case, and a factor of 0.45 is used for the maximum case. These factors are based on physicochemical properties and analogy to studies on TCDD absorption from fly ash (Poiger and Schlatter, 1980; McConnell et al., 1984; Lucier et al., 1986; Van Den Berg et al., 1986).

Using these assumptions, CDI estimates of ingestion of contaminants from incidental soil ingestion by children at the Dorney Road Landfill site are calculated as follows:

$$CDI = \frac{(Cs)(I)(AI)(E)(Yr)(X)}{(BW)(DY)(YL)}$$

where

CDI = chronic daily intake (mg/kg/day)

Cs = chemical concentration in soil (mg/kg)

I = amount of soil ingested (mg/event)

AI = differential absorption factor (0.51 and 0.45 for PCBs and PAHs, 1.0 for all other chemicals)

E = number of exposure events per year

Yr = duration of exposure in years

X = conversion factor 10^{-6} (kg/mg)

BW = average body weight in kg

DY = days in a year (365)

YL = years in lifetime or in the period over which risk is being estimated (70-year lifetime for carcinogens, 5 years for noncarcinogens).

CDIs for dermal absorption of chemical contaminants for children are calculated as follows:

$$CDI = \frac{(Cs)(CD)(E)(Yr)(Z)(ABS)}{(BW)(DY)(YL)}$$

where

CDI = chronic daily intake (mg/kg/day)

Cs = chemical concentration in soil (mg/kg)

CD = contact rate of soil (g/event)

E = number of exposure events per year

Yr = duration of exposure in years

Z = conversion factor 10^{-3} (kg/g)

ABS = dermal absorption factor

BW = average body weight in kg

DY = days in a year (365)

YL = years in lifetime or in the period over which risk is being estimated (70-year lifetime for carcinogens, 5 years for noncarcinogens).

The total CDI associated with direct contact with soils is the sum of the CDIs from incidental ingestion and dermal absorption.

Using these assumptions, the average and maximum plausible chronic daily intakes (CDIs) for exposure of teenagers and adults on-site are presented in Tables 6-19 and 6-20, respectively. The potential carcinogenic and noncarcinogenic risks associated with the estimated CDIs also are shown in Tables 6-19 and 6-20.

The excess lifetime cancer risk is $2x10^{-8}$ under the average case and $4x10^{-6}$ under the maximum plausible case for teenagers, and $2x10^{-7}$ and $3x10^{-5}$ for adults under average case and maximum case assumptions. The total carcinogenic risk under the maximum plausible case is due to potential exposure to arsenic, PCBs, and carcinogenic PAHs. Exposure to chemicals exhibiting noncarcinogenic effects appears to present a low probability of adverse health effects based on the conditions of average case, as the individual CDI:RfD ratios and the hazard indices for noncarcinogenic exposure are less than one. However, with the maximum plausible case assumptions, the hazard index is greater than one, primarily due to the high lead content in the soil.

Table 6-19

Daily Intakes and Risks Associated with Direct Contact by Teenagers with Soils at the Dorney Road Landfill Site

Current-Use Scenario

Dorney Road RI

A. Carcinogens

Chemical	Soil Concentrations (mg/kg) Geometric Mean	Soil Concentrations (mg/kg) Maximum	Quantity of Chemical Ingested and Absorbed (mg/kg/day) Average Case	Quantity of Chemical Ingested and Absorbed (mg/kg/day) Plausible Maximum Case	Quantity of Chemical Absorbed Dermally (mg/kg/day) Average Case	Quantity of Chemical Absorbed Dermally (mg/kg/day) Plausible Maximum Case	Chronic Daily Intake Over 70-Year Lifetime[a] (mg/kg/day) Average Case	Chronic Daily Intake Over 70-Year Lifetime[a] (mg/kg/day) Plausible Maximum Case	Potency[c] Factor $(mg/kg/day)^{-1}$	Extra Lifetime Cancer Risk Average Case	Extra Lifetime Cancer Risk Plausible Maximum Case
PAHs	1.13E+00	8.31E+00	3.39E-10	6.90E-08	4.14E-11	1.75E-07	3.80E-10	2.43E-07	1.15E+01	4.37E-09	2.80E-06
PCB	NA	6.50E-01	NE	5.40E-09	NE	4.78E-08	NE	5.32E-08	7.00E+00	NE	3.72E-07
Arsenic	5.83E+00	1.60E+01	1.22E-08	2.96E-07	b	b	1.22E-08	2.96E-07	1.50E+00	1.84E-08	4.44E-07
Benzene	2.26E-03	1.00E-03	4.75E-12	1.85E-11	4.14E-12	1.05E-10	8.88E-12	1.24E-10	5.20E-02	4.62E-13	6.42E-12
Chloroform	2.85E-03	7.20E-02	5.99E-12	1.33E-09	5.22E-12	7.56E-09	1.12E-11	8.89E-09	8.10E-02	9.07E-13	7.20E-10
Bis(ethylhexyl) phthalate	2.06E-01	2.00E+01	4.33E-10	3.70E-07	3.77E-10	2.10E-06	8.10E-10	2.47E-06	8.30E-03	6.72E-12	2.05E-08
Dieldrin	9.38E-03	8.80E-02	1.97E-11	1.63E-09	1.72E-11	9.24E-09	3.69E-11	1.09E-08	3.00E+01	1.11E-09	3.26E-07
TOTAL										2.39E-08	3.96E-06

000233

ORIGINAL (Red)

Table 6-19 (continued)

Daily Intakes and Risks Associated with Direct Contact by Teenagers with Soils at the Dorney Road Landfill Site

Current-Use Scenario

Dorney Road RI

B. Noncarcinogens

Chemical	Soil Concentrations (mg/kg)		Quantity of Chemical Ingested and Absorbed (mg/kg/day)		Quantity of Chemical Absorbed Dermally (mg/kg/day)		Chronic Daily Intake Over Exposure Period[a] (mg/kg/day)		Reference Dose (RfD)[c] (mg/kg/day)	CDI:RfD Risk	
	Geometric Mean	Maximum	Average Case	Plausible Maximum Case	Average Case	Plausible Maximum Case	Average Case	Plausible Maximum Case		Average Case	Plausible Maximum Case
Bis(ethylhexyl) phthalate	2.06E-01	2.00E+01	6.16E-09	5.18E-06	5.36E-09	2.94E-05	1.15E-08	3.46E-05	2.00E-02	5.76E-07	1.73E-03
Di-N-butyl phthate	2.14E-01	2.00E+00	6.40E-09	5.18E-07	5.56E-09	2.94E-06	1.20E-08	3.46E-06	1.00E-01	1.20E-07	3.46E-05
Phenol	1.72E-01	4.10E-01	5.14E-09	1.06E-07	4.47E-09	6.03E-07	9.61E-09	7.09E-07	4.00E-02	2.40E-07	1.77E-05
4-Methyl pentanone	NA	4.70E-02	NE	1.22E-08	NE	6.92E-08	NE	8.13E-08	5.00E-02	NE	1.63E-06
Chlorobenzene	2.81E-03	2.40E-02	8.40E-11	6.22E-09	7.31E-11	3.53E-08	1.57E-10	4.15E-08	2.70E-02	5.82E-09	1.54E-06
Ethylbenzene	2.82E-03	4.10E-02	8.43E-11	1.06E-08	7.33E-11	6.03E-08	1.58E-10	7.09E-08	1.00E-01	1.58E-09	7.09E-07
4-Methylphenol	2.23E-01	3.40E+00	6.66E-09	8.81E-07	5.79E-09	5.00E-06	1.25E-08	5.88E-06	5.00E-02	2.49E-07	1.18E-04
Naphthalene	1.85E+02	1.22E+03	5.54E-06	3.15E-04	4.82E-06	1.79E-03	1.04E-05	2.10E-03	4.10E-02	2.53E-04	5.13E-02
Beryllium	2.76E+00	6.30E+00	8.25E-08	1.63E-06	b	b	8.25E-08	1.63E-06	5.00E-03	1.65E-05	3.26E-04
Chromium	2.32E+01	1.58E+03	6.92E-07	4.09E-04	b	b	6.92E-07	4.09E-04	5.00E-03	1.38E-04	8.18E-02
Copper	2.40E+01	2.16E+02	7.18E-07	5.59E-05	b	b	7.18E-07	5.59E-05	3.70E-02	1.94E-05	1.51E-03
Lead	1.58E+02	9.06E+04	4.73E-06	2.35E-02	b	b	4.73E-06	2.35E-02	6.00E-04	7.88E-03	3.91E+01
Mercury	1.30E-01	2.30E-01	3.89E-09	5.96E-08	b	b	3.89E-09	5.96E-08	1.40E-03	2.78E-06	4.25E-05
Nickel	5.51E+01	3.58E+03	1.65E-06	9.27E-04	b	b	1.65E-06	9.27E-04	2.00E-02	8.23E-05	4.64E-02
Thallium	1.77E+00	3.70E+00	5.29E-08	1.11E-07	b	b	5.29E-08	1.11E-07	4.00E-04	1.32E-04	2.78E-04
Zinc	1.42E+02	4.72E+02	4.23E-06	1.22E-04	b	b	4.23E-06	1.22E-04	2.10E-01	2.02E-05	5.82E-04
TOTAL										8.54E-03	3.93E+01

000234

Table 6-19 (continued)

Daily Intakes and Risks Associated with Direct Contact by Teenagers with Soils at the Dorney Road Landfill Site

Current-Use Scenario

Dorney Road RI

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[a] Chronic daily intake (averaged over a 70-year lifetime for carcinogens, averaged over the exposure period for noncarcinogens) is the sum of the daily intake from the ingestion pathway and the dermal pathway. Calculated as follows:

Ingestion: $CDI = \frac{(Cs)(I)(AI)(E)(Yr)(X)}{(BW)(DY)(YL)}$ Dermal absorption: $CDI = \frac{(Cs)(CD)(E)(Yr)(Z)(Abs)}{(BW)(DY)(YL)}$

where Cs = concentration in soil; geometric means used for average case and maximum concentrations used for maximum plausible case.

Definitions and values for these parameters are found in Section 6.4.4.1 and Table 6-18. [b] Dermal absorption could not be evaluated for metals.

[c] Potency factors and reference doses are listed in Table 6-17.

NA - not applicable. Only detected in one sample, and use of one-half of the detection limit in calculating the mean results in a mean concentration that is less than the detection limit.

NE - not evaluated.

000235

Table 6-20

Daily Intakes and Risks Associated with Direct Contact by Adults with Soils at the Dorney Road Landfill Site

Current-Use Scenario

Dorney Road RI

A. Carcinogens

Chemical	Soil Concentrations (mg/kg)		Quantity of Chemical Ingested and Absorbed (mg/kg/day)		Quantity of Chemical Absorbed Dermally (mg/kg/day)		Chronic Daily Intake Over 70-Year Lifetime (mg/kg/day) [a]		Potency Factor [c] $(mg/kg/day)^{-1}$	Extra Lifetime Cancer Risk	
	Geometric Mean	Maximum	Average Case	Plausible Maximum Case	Average Case	Plausible Maximum Case	Average Case	Plausible Maximum Case		Average Case	Plausible Maximum Case
PAHs	1.13E+00	8.31E+00	2.94E-09	5.54E-07	1.13E-09	1.43E-06	4.07E-09	1.98E-06	1.15E+01	4.68E-08	2.28E-05
PCB	NA	6.50E-01	NE	4.34E-08	NE	3.91E-07	NE	4.35E-07	7.00E+00	NE	3.04E-06
Arsenic	5.83E+00	1.60E+01	9.97E-08	2.37E-06	NE	NE	9.97E-08	2.37E-06	1.50E+00	1.50E-07	3.56E-06
Benzene	2.26E-03	1.00E-03	3.86E-11	1.48E-10	1.13E-10	8.60E-10	1.52E-10	1.01E-09	5.20E-02	7.89E-12	5.24E-11
Chloroform	2.85E-03	7.20E-02	4.87E-11	1.07E-08	1.42E-10	6.19E-08	1.91E-10	7.26E-08	8.10E-02	1.55E-11	5.88E-09
Bis(ethylhexyl) phthalate	2.06E-01	2.00E+01	3.52E-09	2.97E-06	1.03E-08	1.72E-05	1.38E-08	2.02E-05	8.30E-03	1.15E-10	1.67E-07
Dieldrin	9.38E-03	8.80E-02	1.97E-11	1.63E-09	4.69E-10	7.57E-08	4.89E-10	7.73E-08	3.00E+01	1.47E-08	2.32E-06
TOTAL										2.11E-07	3.19E-05

ORIGINAL (Red)

Table 6-20 (continued)

Daily Intakes and Risks Associated with Direct Contact by Adults
with Soils at the Dorney Road Landfill Site

Current-Use Scenario

Dorney Road RI

B. Noncarcinogens

Chemical	Soil Concentrations (mg/kg) Geometric Mean	Maximum	Quantity of Chemical Ingested and Absorbed (mg/kg/day) Average Case	Plausible Maximum Case	Quantity of Chemical Absorbed Dermally (mg/kg/day) Average Case	Plausible Maximum Case	Chronic Daily Intake Over Exposure Period[a] (mg/kg/day) Average Case	Plausible Maximum Case	Reference Dose (RfD)[c] (mg/kg/day)	CDI:RfD Risk Average Case	Plausible Maximum Case
Bis(ethylhexyl) phthalate	2.06E-01	2.00E+01	4.84E-09	4.07E-06	1.38E-08	2.36E-05	1.86E-08	2.77E-05	2.00E-02	9.32E-07	1.38E-03
Di-N-butyl phthalate	2.14E-01	2.00E+00	5.03E-09	4.07E-07	1.43E-08	2.36E-06	1.94E-08	2.77E-06	1.00E-01	1.94E-07	2.77E-05
Phenol	1.72E-01	4.10E-01	4.04E-09	8.34E-08	1.15E-08	4.84E-07	1.56E-08	5.67E-07	4.00E-02	3.89E-07	1.42E-05
4-Methyl pentanone	NA	4.70E-02	NE	9.56E-09	NE	5.55E-08	NE	6.50E-08	5.00E-02	NE	1.30E-06
Chlorobenzene	2.81E-03	2.40E-02	6.60E-11	4.88E-09	1.88E-10	2.83E-08	2.54E-10	3.32E-08	2.70E-02	9.42E-09	1.23E-06
Ethylbenzene	2.82E-03	4.10E-02	6.63E-11	8.34E-09	1.89E-10	4.84E-08	2.55E-10	5.67E-08	1.00E-01	2.55E-09	5.67E-07
4-Methylphenol	2.23E-01	3.40E+00	5.24E-09	6.92E-07	1.49E-08	4.01E-06	2.02E-08	4.71E-06	5.00E-02	4.03E-07	9.41E-05
Naphthalene	1.85E+02	1.22E+03	4.35E-06	2.47E-04	1.24E-05	1.43E-03	1.68E-05	1.68E-03	4.10E-02	4.09E-04	4.10E-02
Beryllium	2.76E+00	6.40E+00	6.49E-08	1.30E-06	b	b	6.49E-08	1.30E-06	5.00E-03	1.30E-05	2.60E-04
Chromium	2.32E+01	1.58E+03	5.44E-07	3.22E-04	b	b	5.44E-07	3.22E-04	5.00E-03	1.09E-04	6.43E-02
Copper	2.40E+01	2.16E+02	5.64E-07	4.40E-05	b	b	5.64E-07	4.40E-05	3.70E-02	1.52E-05	1.18E-03
Lead	1.58E+02	9.06E+04	3.72E-06	1.84E-02	b	b	3.72E-06	1.84E-02	6.00E-04	6.20E-03	3.07E+01
Mercury	1.30E-01	2.30E-01	3.05E-09	4.68E-08	b	b	3.05E-09	4.68E-08	1.40E-03	2.18E-06	3.34E-05
Nickel	5.51E+01	3.58E+03	1.29E-06	7.29E-04	b	b	1.29E-06	7.29E-04	2.00E-02	6.47E-05	3.64E-02
Thallium	1.77E+00	3.70E+00	4.16E-08	8.70E-08	b	b	4.16E-08	8.70E-08	4.00E-04	1.04E-04	2.18E-04
Zinc	1.42E+02	4.72E+02	3.33E-06	9.61E-05	b	b	3.33E-06	9.61E-05	2.10E-01	1.58E-05	4.57E-04
TOTAL										6.93E-03	3.08E+01

ORIGINAL (Red)

000237

Table 6-20 (continued)

Daily Intakes and Risks Associated with Direct Contact by Adults with Soils at the Dorney Road Landfill Site

Current-Use Scenario

Dorney Road RI

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[a]Chronic daily intake (averaged over a 70-year lifetime for carcinogens, averaged over the exposure period for noncarcinogens) is the sum of the daily intake from the ingestion pathway and the dermal pathway. Calculated as follows:

Ingestion: $CDI = \frac{(Cs)(I)(AI)(E)(Yr)(X)}{(BW)(DY)(YL)}$ Dermal absorption: $CDI = \frac{(Cs)(CD)(E)(Yr)(Z)(Abs)}{(BW)(DY)(YL)}$

where Cs = concentration in soil; geometric means used for average case and maximum concentrations used for maximum plausible case. Definitions and values for these parameters are found in Section 6.4.4.1 and Table 6-18. [b]Dermal absorption could not be evaluated for metals.

[c]Potency factors and reference doses are listed in Table 6-17.

NA - not applicable. Only detected in one sample, and use of one-half of the detection limit in calculating the mean results in a mean concentration that is less than the detection limit.

NE - not evaluated.

ORIGINAL (Red)

Direct Contact with Surface Water On-Site

As described, the site has several marsh areas and man-made ponds (designed to hold surface water run-off). Under this scenario, both teenagers and adults are assumed to come into contact with surface water during hiking or hunting. It is not expected that recreational swimming occurs nor is fishing, with subsequent ingestion of fish, a likely scenario. It is assumed, however, that during the course of duck hunting, which usually involves being in a boat or duck blind in the marshes, these persons will get wet. In that case such individuals would be exposed through dermal absorption and incidental ingestion. This exposure scenario will have elements of absorption as described for dermal absorption from soil and absorption as expected when a contaminant is carried through the skin as a solute in water as in a swimming episode. It is assumed that this exposure can be more closely approximated by assuming a brief swimming-type episode in which dermal absorption is assumed to occur only across exposed skin. Absorption through wet clothes was not considered. The frequency of events and the years of exposure, and the amount of skin surface area exposed is assumed to be the same and are assumed to coincide with the recreational activities as described in the previous section.

These and other assumptions used to calculate exposure to surface area are summarized in Table 6-21.

Significant dermal absorption of the metals detected in on-site surface water is not expected because the concentrations are low, and because the permeability of even hydrated skin to metal ions is low. Further, the episodic nature and short-duration of swimming events also minimizes the potential for significant exposure. As a result, intakes from dermal absorption of metals while swimming is not evaluated. A simplified approach presented in the Draft Superfund Exposure Assessment Manual (Versar, 1986) is used to estimate exposure via dermal absorption while swimming. This approach assumes that a contaminant is carried through the skin as a solute in water that is absorbed (rather than being preferentially absorbed independently of the water). Dermal exposure per event is calculated as follows:

$$DEX = (D)(A)(C)(Flux)$$

where

DEX = estimated dermal exposure per event (mass of contaminant per event),

D = duration of exposure event (hours),

A = skin surface available for contact (cm^2),

C = contaminant concentration in water (weight fraction), and

Flux = flux rate of water and chemical across skin ($mass/cm^2/hr$).

000239

Table 6-21

Assumptions for Use in the Exposure Assessment for Direct Contact with Surface Water by Teenagers and Adults at the Dorney Road Site

Dorney Road RI

(Current-Use Scenario)

Parameter	Teenager Average	Teenager Plausible	Adult Average	Adult Plausible
Age of people exposed	14-18	14-18	19+	19+
Frequency of exposure (E)	12	52	12	52
Duration of exposure (Yr)	5	5	51	51
Average body weight over period of exposure (BW)	55	55	70	70
Incidental ingestion of contaminated water (I)	10 ml	10 ml	10 ml	10 ml
Percent of compounds absorbed from ingested water (AI)	100%	100%	100%	100%
Duration of exposure event (D)	0.5	1	0.5	1
Skin surface area (cm^2)(A)	860	3790	2940	3870
Flux ratio of water across skin ($mg/cm^2/hr$)	0.5	1	0.5	1
Lifetime (carcinogens) (YL)	70	70	70	70
Period of exposure (non-carcinogens) (YL)	5	5	51	51

ORIGINAL (Red)

The flux rate of water across the skin boundary is assumed to be the factor controlling the contaminant absorption rate. Although the Exposure Assessment Manual suggests using a flux rate of 0.5 $mg/cm^2/hr$, more recent data suggest this value may be closer to 1 $mg/cm^2/hr$ (Brown et al., 1984). In this assessment, 0.5 $mg/cm^2/hr$ will be used to evaluate the average exposure scenario, and 1 $mg/cm^2/hr$ will be used to evaluate the maximum plausible exposure scenario. The dose per event from dermal absorption is presented in Tables 6-22 and 6-23.

In addition to dermal contact, it is possible that a person may accidentally swallow water. For the purpose of evaluating this potential exposure, it is assumed that an individual will ingest approximately 10 ml of water during each episode. All of the chemicals of concern detected in on-site lakes will be assessed in this exposure pathway. This intake (in mg) of chemical during each event is calculated by multiplying the concentration of the contaminant in surface water (mg/l) by the volume of water ingested (10 ml). The dose is calculated by dividing the intake by body weight, either 55 kg for a teenager or 70 kg for an adult. The dose per event from incidental ingestion for each chemical of potential concern is presented in Tables 6-22 and 6-23 along with the associated risks.

As shown in Tables 6-22 and 6-23, the hazard index for the combined dermal absorption and incidental ingestion exposure during swimming is less than one, indicating a low probability of adverse health effects under the exposure conditions assumed.

Direct Contact with Sediments Found On-Site

Sediment samples were taken at the same time and from the same locations as the surface water samples. These sediment samples were obtained from the bottom of the on-site surface waters and are assumed to illustrate migration of surface soil contaminants into surface waters at the site. Again it is assumed that only persons present on-site for recreational activities, such as hunting or hiking, would come in contact with sediments. As with surface water exposure, contact with contaminants in the sediment is assumed to occur as a person moves through the marshes or walks in shallow surface water areas. While contact with sediment is likely to occur primarily with the feet while walking and feet most likely will be covered (shoes, waders), the sediment may be disturbed in the process and come in contact with exposed skin. The primary pathway for exposure to contaminants in the sediment is by direct contact and dermal absorption. The assumptions used in the assessment of risk by way of this exposure route are presented in Table 6-24. As with direct dermal contact with soil, it is assumed that exposure may occur during the teenage years or occur throughout an adult's lifetime (19-70 years). Age-specific body weights and surface areas were assumed based on the information discussed previously. The equation described for dermal absorption was used. Average case parameters were evaluated using the geometric mean of contaminant concentrations, while the maximum plausible case utilized higher parameter values and the maximum contaminant concentrations.

Table 6-22

Daily Intakes and Risks Associated with Direct Contact by Teenagers
with Surface Water at the Dorney Road Landfill Site

Current-Use Scenario

Dorney Road RI

A. Carcinogens

Chemical	Surface Water Concentrations (ug/l)		Quantity of Chemical Ingested and Absorbed (mg/kg/day)		Quantity of Chemical Absorbed Dermally (mg/kg/day)		Chronic Daily Intake Over 70-Year Lifetime (mg/kg/day)[a]		Potency Factor (mg/kg/day)$^{-1}$ [b]	Extra Lifetime Cancer Risk	
	Geometric Mean	Maximum	Average Case	Plausible Maximum Case	Average Case	Plausible Maximum Case	Average Case	Plausible Maximum Case		Average Case	Plausible Maximum Case
1,1-Dichloroethane	NA	9.00E+00	NE	3.84E-06	NE	6.31E-06	NE	1.02E-05	9.10E-02	NE	9.28E-07

Table 6-22 (continued)

Daily Intakes and Risks Associated with Direct Contact by Teenagers with Surface Water at the Dorney Road Landfill Site

Current-Use Scenario

Dorney Road RI

B. Noncarcinogens

Chemical	Surface Water Concentrations (ug/l) Geometric Mean	Surface Water Concentrations (ug/l) Maximum	Quantity of Chemical Ingested and Absorbed (mg/kg/day) Average Case	Quantity of Chemical Ingested and Absorbed (mg/kg/day) Plausible Maximum Case	Quantity of Chemical Absorbed Dermally (mg/kg/day) Average Case	Quantity of Chemical Absorbed Dermally (mg/kg/day) Plausible Maximum Case	Chronic Daily Intake Over Exposure Period[a] (mg/kg/day) Average Case	Chronic Daily Intake Over Exposure Period[a] (mg/kg/day) Plausible Maximum Case	Reference Dose(RfD)[c] (mg/kg/day)	CDI:RfD Risk Average Case	CDI:RfD Risk Plausible Maximum Case
Zinc	1.91E+01	3.40E+01	1.14E-07	8.81E-07	b	b	1.14E-07	8.81E-07	2.10E-01	5.42E-07	4.19E-06
Manganese	1.08E+03	3.10E+04	6.47E-06	8.03E-04	b	b	6.47E-06	8.03E-04	2.20E-01	2.94E-05	3.65E-03
Lead	8.80E+00	3.00E+01	5.26E-08	7.77E-07	b	b	5.26E-08	7.77E-07	6.00E-04	8.77E-05	1.30E-03
TOTAL										1.18E-04	4.95E-03

[a] Chronic daily intake, averaged over the exposure period for noncarcinogens, is the sum of the daily intake from the ingestion pathway and the dermal pathway. Calculated as follows:

Ingestion: $CDI = \frac{(Cw)(I)(AI)(E)(Yr)(X)}{(BW)(DY)(YL)}$ Dermal absorption: CDI = DEX = (D)(A)(Cw)(Flux)

where Cw = concentration in surface water; geometric means used for average case and maximum concentrations used for maximum plausible case. Definitions and values for these parameters are found in Section 6.4.4.1 and Table 6-21. X = conversion factor l/1000 ml.

[b] Dermal absorption could not be evaluated for metals.

[c] Potency factors and reference doses are listed in Table 6-17.

NA - not applicable. Only detected in one sample, and use of one-half of the detection limit in calculating the mean results in a mean concentration that is less than the detection limit.

NE - not evaluated.

Table 6-23

Daily Intakes and Risks Associated with Direct Contact by Adults with Surface Water at the Dorney Road Landfill Site

Current-Use Scenario

Dorney Road RI

A. Carcinogens

Chemical	Surface Water Concentrations (ug/l)		Quantity of Chemical Ingested and Absorbed (mg/kg/day)		Quantity of Chemical Absorbed Dermally (mg/kg/day)		Chronic Daily Intake Over 70-Year Lifetime (mg/kg/day)[a]		Potency Factor[c] $(mg/kg/day)^{-1}$	Extra Lifetime Cancer Risk	
	Geometric Mean	Maximum	Average Case	Plausible Maximum Case	Average Case	Plausible Maximum Case	Average Case	Plausible Maximum Case		Average Case	Plausible Maximum Case
1,1-Dichloroethane	NA	9.00E+00	NE	1.33E-04	NE	5.16E-05	NE	1.85E-04	9.10E-02	NE	1.68E-05

000244

ORIGINAL (Red)

Table 6-23 (continued)

Daily Intakes and Risks Associated with Direct Contact by Adults with Surface Water at the Dorney Road Landfill Site

Current-Use Scenario

Dorney Road RI

B. Noncarcinogens

Chemical	Surface Water Concentrations (ug/l) Geometric Mean	Maximum	Quantity of Chemical Ingested and Absorbed (mg/kg/day) Average Case	Plausible Maximum Case	Quantity of Chemical Absorbed Dermally (mg/kg/day) Average Case	Plausible Maximum Case	Chronic Daily Intake Over Exposure Period[a] (mg/kg/day) Average Case	Plausible Maximum Case	Reference Dose (RfD)[c] (mg/kg/day)	CDI:RfD Risk Average Case	Plausible Maximum Case
Zinc	1.91E+01	3.40E+01	9.15E-07	7.06E-06	b	b	9.15E-07	7.06E-06	2.10E-01	4.36E-06	3.36E-05
manganese	1.08E+03	3.10E+04	5.19E-05	6.44E-03	b	b	5.19E-05	6.44E-03	2.20E-01	2.34E-04	2.93E-02
Lead	8.80E+00	3.00E+01	4.22E-07	6.23E-06	b	b	4.22E-07	6.23E-06	6.00E-04	7.03E-04	1.04E-02
TOTAL										9.41E-04	3.97E-02

[a] Chronic daily intake, averaged over the exposure period for noncarcinogens, is the sum of the daily intake from the ingestion pathway and the dermal pathway. Calculated as follows:

Ingestion: $CDI = \frac{(Cw)(I)(AI)(E)(Yr)(X)}{(BW)(DY)(YL)}$ Dermal absorption: CDI = DEX = (D)(A)(Cw)(Flux)

where Cw = concentration in surface water; geometric means used for average case and maximum concentrations used for maximum plausible case. Definitions and values for these parameters are found in Section 6.4.4.1 and Table 6-21. X = conversion factor l/1000 ml.

[b] Dermal absorption could not be evaluated for metals.

[c] Potency factors and reference doses are listed in Table 6-17.

NA - not applicable. Only detected in one sample, and use of one-half of the detection limit in calculating the mean results in a mean concentration that is less than the detection limit.

NE - not evaluated.

ORIGINAL
(Red)

Table 6-24

Assumptions for Use in the Exposure Assessment for Direct Contact with Sediment by Teenagers and Adults at The Dorney Road Site

(Current-Use Scenario)

Dorney Road RI

Parameter	Teenager Average	Teenager Plausible	Adult Average	Adult Plausible
Age of people exposed	14-18	14-18	19+	19+
Frequency of exposure (E)	12	52	12	52
Duration of exposure (YR)	5	5	51	51
Average body weight over period of exposure (BW)	55	55	70	70
Soil contact rate for use in dermal adsorption estimate (CD)	0.43	5.68	1.45	5.80
Percent of organic compound absorbed dermally from skin (ABS)				
- PAHs	0.2%	2%	0.2%	2%
- PCBs	7%	7%	7%	7%
- Other organic compounds	10%	10%	10%	10%
Percent of inorganic compound absorbed dermally from skin	negligible	negligible	negligible	negligible
Lifetime (carcinogens) (YL)	70	70	70	70
Period of exposure (non-carcinogens) (YL)	5	5	51	51

ORIGINAL (Red)

As with estimates discussed previously, the chronic daily intake is averaged over a 70-year lifetime when considering cancer effects, but only over the exposure duration for non-cancer effects. Daily intakes and associated risks are presented in Tables 6-25 and 6-26. Extra lifetime cancer risks are extremely low ($1x10^{-10}$ and $1x10^{-9}$) for teenagers and adults, respectively. The hazard indices for noncancer effects are also extremely low, indicating that exposure by way of this pathway does not present a significant hazard.

Exposure Through Contact With Leachate Seeps

Exposure to contaminants in leachate seeps may occur through direct contact by teenagers and adults engaged in hunting or other leisure activities. Table 6-27 lists the assumptions used in estimating the exposures to both teenagers and adults from contact with seeps, however, the same skin surface area is applied. Because the seeps are liquid it is assumed that those exposed will have contact only with the feet while walking through the seeps. Consequently, only dermal absorption of chemicals is considered. Average and maximum plausible cases are considered, based on geometric mean and maximum concentrations detected in residential wells. For the leachate seeps geometric mean concentrations were not available, therefore only maximum plausible scenarios were addressed.

The maximum plausible chronic daily intakes (CDIs) for teenagers and adults exposed to contaminants from contact with leachate seeps are presented in Tables 6-28 and 6-29, respectively. The potential noncarcinogenic risks associated with the estimated CDIs also are shown in Tables 6-28 and 6-29.

Current-Use of Groundwater

Ingestion of contaminants from groundwater is considered under a current-use scenario. For estimates of current-use exposure, levels of contaminants as measured in the seven existing residential wells southwest and northwest of the site are assumed to be indicative of the groundwater contaminant levels in these areas. It is estimated that a person living in this area would consume 2 liters of well water per day for a lifetime of 70 years. Potential risks associated with other uses of well water, i.e. cooking and watering of lawns or gardens, have not been addressed. Average body weight is assumed to be 70 kg. Average and maximum plausible cases are considered, based on geometric mean and maximum concentrations detected in residential wells.

The chronic daily intake for ingestion of groundwater is given by

$$CDI = \frac{(C_W)(IR)}{BW}$$

where

CDI = chronic daily intake (mg/kg/day),

C_W = concentration of contaminants in groundwater at the exposure point (mg/l),

Table 6-25

Daily Intakes and Risks Associated with Direct Contact by Teenagers with Sediment at the Dorney Road Landfill Site

Current-Use Scenario

Dorney Road RI

A. Carcinogens

Dermally	Sediment Year Lifetime (mg/kg)		Quantity of Chemical Absorbed (mg/kg/day)		Chronic Daily Intake Over 70-Extra Lifetime (mg/kg/day)[a]			Concentrations Cancer Risk	
Chemical	Geometric Mean	Maximum	Average Case	Plausible Maximum Case	Average Case	Plausible Maximum Case	Potency[c] Factor $(mg/kg/day)^{-1}$	Average Case	Plausible Maximum Case
Chloroform	NA	6.00E-03	NE	6.30E-10	NE	6.30E-10	8.10E-02	NE	5.10E-11
Bis(ethylhexyl) phthalate	NA	7.80E-02	NE	8.19E-09	NE	8.19E-09	8.30E-03	NE	6.80E-11
Arsenic	8.28E+00	1.41E+01	b	b	b	b	1.50E+00	b	b
TOTAL									1.19E-10

Table 6-25 (continued)

Daily Intakes and Risks Associated with Direct Contact by Teenagers with Sediment at the Dorney Road Landfill Site

Current-Use Scenario

Dorney Road RI

B. Noncarcinogens

Chemical	Sediment Concentrations (mg/kg) Geometric Mean	Maximum	Quantity of Chemical Absorbed Dermally (mg/kg/day) Average Case	Plausible Maximum Case	Chronic Daily Intake Over Exposure Period[a] (mg/kg/day) Average Case	Plausible Maximum Case	Reference Dose (RfD)[c] (mg/kg/day)	Extra Lifetime CDI:RfD Average Case	Plausible Maximum Case
Ethylbenzene	NA	4.00E-03	NE	5.89E-09	NE	5.89E-09	1.00E-01	NE	5.89E-08
Bis(ethylhexyl) phthalate	NA	7.80E-02	NE	1.15E-07	NE	1.15E-07	2.00E-02	NE	5.74E-06
4-Methylphenol	NA	5.20E-02	NE	7.65E-08	NE	7.65E-08	5.00E-02	NE	1.53E-04
Beryllium	3.50E+00	5.20E+00	b	b	b	b	5.00E-03	b	b
Chromium	8.70E+00	1.10E+01	b	b	b	b	5.00E-03	b	b
Copper	2.56E+01	9.90E+01	b	b	b	b	3.70E-02	b	b
Lead	2.18E+01	9.50E+01	b	b	b	b	6.00E-04	b	b
Mercury	1.35E-01	1.90E-01	b	b	b	b	1.40E-03	b	b
Nickel	4.79E+01	5.20E+01	b	b	b	b	2.00E-02	b	b
Zinc	1.20E+02	1.52E+02	b	b	b	b	2.10E-01	b	b
Barium	8.00E+01	1.09E+02	b	b	b	b	5.10E-02	b	b
Manganese	1.14E+03	1.60E+03	b	b	b	b	2.20E-01	b	b
TOTAL									7.33E-06

ORIGINAL (Red)

000249

Table 6-25 (continued)

Daily Intakes and Risks Associated with Direct Contact by Teenagers with Sediment at the Dorney Road Landfill Site

Current-Use Scenario

Dorney Road RI

[a] Chronic daily intake (averaged over a 70-year lifetime for carcinogens, averaged over the exposure period for noncarcinogens) is as follows:

$$\text{Dermal absorption: } CDI = \frac{(Cs)(CD)(E)(Yr)(Z)(Abs)}{(BW)(DY)(YL)}$$

where Cs = concentration in sediment; geometric means used for average case and maximum concentrations used for maximum plausible case. Definitions and values for these parameters are found in Section 6.4.4.1 and Table 6-24.

[b] Dermal absorption could not be evaluated for metals.

[c] Potency factors and reference doses are listed in Table 6-17.

NA - not applicable. Only detected in one sample, and use of one-half of the detection limit in calculating the mean results in a mean concentration that is less than the detection limit.

NE - not evaluated.

Table 6-26

Daily Intakes and Risks Associated with Direct Contact by Adults with Sediment at the Dorney Road Landfill Site

Current-Use Scenario

Dorney Road RI

A. Carcinogens

Chemical	Sediment Concentrations (mg/kg) Geometric Mean	Sediment Concentrations (mg/kg) Maximum	Quantity of Chemical Absorbed Dermally (mg/kg/day) Average Case	Quantity of Chemical Absorbed Dermally (mg/kg/day) Plausible Maximum Case	Chronic Daily[a] Intake Over 70-Year Lifetime (mg/kg/day) Average Case	Chronic Daily[a] Intake Over 70-Year Lifetime (mg/kg/day) Plausible Maximum Case	Potency[c] Factor $(mg/kg/day)^{-1}$	Extra Lifetime Cancer Risk Average Case	Extra Lifetime Cancer Risk Plausible Maximum Case
Chloroform	NA	6.00E-03	NE	5.16E-09	NE	5.16E-09	8.10E-02	NE	4.18E-10
Bis(ethylhexyl) phthalate	NA	7.80E-02	NE	6.71E-08	NE	6.71E-08	8.30E-03	NE	5.57E-10
Arsenic	8.28E+00	1.41E+01	b	b	b	b	1.50E+00	b	b
TOTAL									9.75E-10

Table 6-26 (continued)

Daily Intakes and Risks Associated with Direct Contact by Adults with Sediment at the Dorney Road Landfill Site

Current-Use Scenario

Dorney Road RI

B. Noncarcinogens

Chemical	Sediment Concentrations (mg/kg)		Quantity of Chemical Absorbed Dermally (mg/kg/day)		Chronic Daily Intake Over Exposure Period[a] (mg/kg/day)		Reference Dose (RfD)[c] (mg/kg/day)	CDI:RfD Risk	
	Geometric Mean	Maximum	Average Case	Plausible Maximum Case	Average Case	Plausible Maximum Case		Average Case	Plausible Maximum Case
Ethylbenzene	NA	4.00E-03	NE	4.72E-09	NE	4.72E-09	1.00E-01	NE	4.72E-08
Bis(ethylhexyl) phthalate	NA	7.80E-02	NE	9.21E-08	NE	9.21E-08	2.00E-02	NE	4.60E-06
4-Methylphenol	NA	5.20E-02	NE	6.14E-08	NE	6.14E-08	5.00E-02	NE	1.23E-06
Beryllium	3.50E+00	5.20E+00	b	b	b	b	5.00E-03	b	b
Chromium	8.70E+00	1.10E+01	b	b	b	b	5.00E-03	b	b
Copper	2.56E+01	9.90E+01	b	b	b	b	3.70E-02	b	b
Lead	2.18E+01	9.50E+01	b	b	b	b	6.00E-04	b	b
Mercury	1.35E-01	1.90E-01	b	b	b	b	1.40E-03	b	b
Nickel	4.79E+01	5.20E+01	b	b	b	b	2.00E-02	b	b
Zinc	1.20E+02	1.52E+02	b	b	b	b	2.10E-01	b	b
Barium	8.00E+01	1.09E+02	b	b	b	b	5.10E-02	b	b
Manganese	1.14E+03	1.60E+03	b	b	b	b	2.20E-01	b	b
TOTAL									5.88E-06

ORIGINAL (Red)

0 0 0252

Table 6-26 (continued)

Daily Intakes and Risks Associated with Direct Contact by Adults with Sediment at the Dorney Road Landfill Site

Current-Use Scenario

Dorney Road RI

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[a] Chronic daily intake (averaged over a 70-year lifetime for carcinogens, averaged over the exposure period for noncarcinogens) is as follows:

$$\text{Dermal absorption: } CDI = \frac{(Cs)(CD)(E)(Yr)(Z)(Abs)}{(BW)(DY)(YL)}$$

where Cs = concentration in sediment; geometric means used for average case and maximum concentrations used for maximum plausible case. Definitions and values for these parameters are found in Section 6.4.4.1 and Table 6-24.

[b] Dermal absorption could not be evaluated for metals.

[c] Potency factors and reference doses are listed in Table 6-17.

NA - not applicable. Only detected in one sample, and use of one-half of the detection limit in calculating the mean results in a mean concentration that is less than the detection limit.

NE - not evaluated.

Table 6-27

ORIGINAL (Red)

Assumptions for Use in the Exposure Assessment for Direct Contact with Leachate Seeps by Teenagers and Adults at the Dorney Road Site

Dorney Road RI

(Current-Use Scenario)

Parameter	Teenager Average	Teenager Plausible	Adult Average	Adult Plausible
Age of people exposed	14-18	14-18	19+	19+
Frequency of exposure (E)	6	26	6	26
Duration of exposure (YR)	5	5	51	51
Average body weight over period of exposure (BW)	55	55	70	70
Soil contact rate for use in dermal adsorption estimate (CD)	0.43	5.68	1.45	5.80
Percent of organic compound absorbed dermally from skin (ABS)				
- PAHs	0.2%	2%	0.2%	2%
- PCBs	7%	7%	7%	7%
- Other organic compounds	10%	10%	10%	10%
Percent of inorganic compound absorbed dermally from skin	*	*	*	*
Lifetime (carcinogens) (YL)	70	70	70	70
Period of exposure (noncarcinogens) (YL)	5	5	51	51

* - negligible.

Table 6-28

Daily Intakes and Risks Associated with Direct Contact by Teenagers with Leachate Seeps at the Dorney Road Landfill Site

Current-Use Scenario

Dorney Road RI

A. Noncarcinogens

Chemical	Seep Concentrations (ug/l) Geometric Mean	Seep Concentrations (ug/l) Maximum	Quantity of Chemical Absorbed Dermally (mg/kg/day) Average Case	Quantity of Chemical Absorbed Dermally (mg/kg/day) Plausible Maximum Case	Chronic Daily Intake Over Exposure Period[a] (mg/kg/day) Average Case	Chronic Daily Intake Over Exposure Period[a] (mg/kg/day) Maximum Case	Reference Dose (RfD)[b] (mg/kg/day)	CDI:RfD Risk Average Case	CDI:RfD Risk Plausible Maximum Case
4-Methylpentanone	NA	3.90E-01	NE	2.87E-07	NE	2.87E-07	5.00E-02	NE	5.74E-06
Diethylphthalate	NA	5.60E-01	NE	4.12E-07	NE	4.12E-07	8.00E-01	NE	5.15E-07
Phenol	NA	3.90E-01	NE	2.87E-07	NE	2.87E-07	4.00E-02	NE	7.17E-06
4-Methylphenol	NA	3.70E+00	NE	2.72E-06	NE	2.72E-06	5.00E-02	NE	5.44E-05
Naphthalene	NA	3.10E-01	NE	2.28E-07	NE	2.28E-07	4.10E-02	NE	5.56E-06
TOTAL									7.34E-05

[a] Chronic daily intake (averaged over a 70-year lifetime for carcinogens, averaged over the exposure period for noncarcinogens) is as follows:

Dermal absorption: $CDI = \frac{(Cs)(CD)(E)(Yr)(Z)(Abs)}{(BW)(DY)(YL)}$

where Cs = concentration in seeps; geometric means used for average case and maximum concentrations used for maximum plausible case. Definitions and values for these parameters are found in Section 6.4.4.1 and Table 6-27.

[b] Reference doses are listed in Table 6-17.

NA - not applicable. Only detected in one sample, and use of one-half of the detection limit in calculating

ORIGINAL (Red)

000255

Table 6-29

Daily Intakes and Risks Associated with Direct Contact by Adults with Leachate Seeps at the Dorney Road Landfill Site

Current-Use Scenario

Dorney Road RI

A. Noncarcinogens

Chemical	Seep Concentrations (ug/l) Geometric Mean	Seep Concentrations (ug/l) Maximum	Quantity of Chemical Absorbed Dermally (mg/kg/day) Average Case	Quantity of Chemical Absorbed Dermally (mg/kg/day) Plausible Maximum Case	Chronic Daily Intake Over Exposure Period[a] (mg/kg/day) Average Case	Chronic Daily Intake Over Exposure Period[a] (mg/kg/day) Maximum Case	Reference Dose (RfD)[b] (mg/kg/day)	CDI:RfD Risk Average Case	CDI:RfD Risk Plausible Maximum Case
4-Methylpentanone	NA	3.90E-01	NE	2.30E-07	NE	2.30E-07	5.00E-02	NE	4.60E-06
Diethylphthalate	NA	5.60E-01	NE	3.31E-07	NE	3.31E-07	8.00E-01	NE	4.13E-07
Phenol	NA	3.90E-01	NE	2.30E-07	NE	2.30E-07	4.00E-02	NE	5.76E-06
4-Methylphenol	NA	3.70E+00	NE	2.18E-06	NE	2.18E-06	5.00E-02	NE	4.37E-05
Naphthalene	NA	3.10E-01	NE	1.83E-07	NE	1.83E-07	4.10E-02	NE	4.46E-06
TOTAL									5.89E-05

[a] Chronic daily intake (averaged over a 70-year lifetime for carcinogens, averaged over the exposure period for noncarcinogens) is as follows:

$$\text{Dermal absorption: } CDI = \frac{(Cs)(CD)(E)(Yr)(Z)(Abs)}{(BW)(DY)(YL)}$$

where Cs = concentration in seeps; geometric means used for average case and maximum concentrations used for maximum plausible case. Definitions and values for these parameters are found in Section 6.4.4.1 and Table 6-27.

[b] Reference doses are listed in Table 6-17.

NA - not applicable. Only detected in one sample, and use of one-half of the detection limit in calculating the mean results in a mean concentration that is less than the detection limit.

NE - not evaluated.

ORIGINAL (Red)

ORIGINAL (Red)

IR = ingestion rate of water (l/day), and

BW = average body weight (kg).

The average and maximum plausible chronic daily intakes (CDIs) for exposure to contaminants from groundwater under current conditions are presented in Table 6-30.

From this same groundwater monitoring data an estimate of exposure from showering with this water is developed according to a model developed by Foster and Chrostowski (1987). Inhalation exposures to volatile organic chemicals are modeled by estimating the rate of chemical release into the air, the buildup and decay of these chemicals in the shower room air, and the quantity of airborne chemicals inhaled while the shower is both on and off. Estimates of inhalation exposure were developed assuming one ten-minute shower per day.

The average and maximum plausible chronic daily intakes (CDIs) for exposure to contaminants from showering with groundwater under current conditions are presented in Table 6-30. The potential carcinogenic and noncarcinogenic risks associated with the estimated CDIs also are shown in Table 6-30.

The potential carcinogenic and noncarcinogenic risks associated with the estimated CDIs for drinking water and showering combined are shown in Table 6-30. From drinking and showering with groundwater from residential wells, the excess lifetime cancer risk is 7×10^{-6} under the average case and 3×10^{-5} under the maximum plausible case.

6.4.4.2 Estimates of Exposure and Assessment of Risks Under Future-Use Conditions

In the absence of future remedial actions and institutional actions limiting access to the site and surrounding area, the routes of exposure quantified for current-use also would apply in the future. In addition, however, different land-use of the site in the future may result in additional exposures. As discussed in Section 6.3, exposure pathways that may potentially be complete in the future are dermal absorption and incidental ingestion of soil by future residents, workers or recreational users of the site, ingestion of groundwater and inhalation of volatile organic chemicals found in groundwater, if used as a residential water supply. Under the assumed potential future site uses, soil exposures could potentially occur from surface and subsurface soil, particularly if the site is regraded during future site use which would expose the soils and waste at greater depths. The concentrations of the chemicals of potential concern that will be used in estimating future exposure are presented in Section 6.2. Waste concentrations of leachable chemicals in soil would be expected to decrease in the future. However, to the extent that the landfill has not been characterized at greater depths, these concentrations and identified chemicals may not be appropriate for use in scenarios involving extensive disturbance of the fill.

Table 6-30

Daily Intake and Risks Associated with Water in Residential Wells at the Dorney Road Landfill Site

Current-Use Scenario

Dorney Road RI

A. Carcinogens

Chemical	Residential Well Water Concentrations (ug/l)		Daily Intake Average Case (mg/kg/day)		Daily Intake Plausible Maximum Case (mg/kg/day)		Chronic Daily Intake[a]		Potency[b] Factor $(mg/kg/day)^{-1}$	Extra Cancer Risk	
	Geometric Mean	Maximum	Drinking Water	Shower	Drinking Water	Shower	Average Case	Plausible Case		Average Case	Maximum Plausible Case
1,1-Dichloroethane	NA	2	NE	NE	5.70E-04	5.47E-05	NE	1.12E-04	9.10E-02	NE	1.02E-05
Tetrachloroethene	2.71	6	7.70E-05	6.31E-05	1.71E-04	1.40E-04	1.40E-04	3.11E-04	5.10E-02	7.14E-06	1.58E-05
Trichloroethylene	NA	9	NE	NE	2.57E-04	2.27E-04	NE	4.84E-04	1.10E-02	NE	5.32E-06
Bis(2-ethylhexyl)-phthalate	NA	2	NE	NE	5.70E-05	NE	NE	5.70E-05	8.30E-03	NE	4.73E-07
TOTAL										7.14E-06	3.18E-05

ORIGINAL (Red)

Table 6-30 (continued)

Daily Intake and Risks Associated with Water in Residential Wells at the Dorney Road Landfill Site

Current-Use Scenario

Dorney Road RI

B. Noncarcinogens

Chemical	Residential Well Water Concentrations (ug/l)		Daily Intake Average Case (mg/kg/day)		Daily Intake Plausible Maximum Case (mg/kg/day)		Chronic Daily Intake[a]		Reference Dose (RfD)[b] (mg/kg/day)	CDI: RfD Risk	
	Geometric Mean	Maximum	Drinking Water	Shower	Drinking Water	Shower	Average Case	Plausible Case		Average Case	Maximum Plausible Case
1,2-Dichloroethylene	NA	22	NE	NE	6.28E-04	6.18E-04	NE	1.25E-03	5.80E-01	NE	1.38E-01
Barium	13.30	31	3.80E-04	NE	8.85E-04	NE	3.80E-04	8.85E-04	5.10E-02	7.45E-03	1.74E-02
Manganese	6.50	83	1.85E-04	NE	2.37E-03	NE	1.85E-04	2.37E-03	2.20E-01	8.41E-04	1.08E-02
Zinc	26.43	448	7.55E-04	NE	1.28E-02	NE	7.55E-04	1.28E-02	2.10E-01	3.60E-03	6.10E-02
TOTAL										1.19E-02	2.27E-01

[a] Chronic daily intake (averaged over a 70-year lifetime for carcinogens, averaged over the exposure period for noncarcinogens) is the sum of the daily intake from the ingestion of drinking water pathway and from inhalation of volatilized chemicals during showering. Drinking water intake calculated as follows:

$$CDI = \frac{Cw\ (2\ l/day)(1\ mg/1000\ ug)}{70\ kg}$$

where Cw = concentration in residential wells; geometric means used for average case and maximum concentrations used for maximum plausible case for both drinking water and showering. Inhalation exposure estimated according to the method of Foster and Chrostowski.

[b] Potency factors and reference doses are listed in Table 6-17.

NA - not applicable. Only detected in one sample, and use of one-half of the detection limit in calculating the mean results in a mean concentration that is less than the detection limit.

NE - not evaluated.

ORIGINAL (Red)

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Exposure and risk under these hypothetical future-use scenarios are discussed in this section. Quantitative estimates of exposure and risk are presented below for residents. Soil exposures and risk to construction workers and future recreational users are discussed.

Direct Contact with Contaminated Soil

People may become exposed to soil contaminants at the Dorney Road site during any construction activity that may take place in the future, and during future use of the site as a residential or recreational area. In all cases, the chemicals of concern can enter the body by absorption through the skin and by incidental ingestion of soil during outdoor activities. Exposures and risks to future residents are discussed quantitatively, whereas those under the other future-use scenarios (recreational or worker) are evaluated qualitatively.

To assess exposures to residents living on the site in the future, it is assumed that an individual could be exposed throughout most of their childhood (1-18 years, average case), or through their entire lifetime (70 years, maximum plausible case). Exposures during these periods will vary because certain factors that influence dose (e.g., amount of soil ingested, body surface area, body weight, etc.) vary with age. Therefore, chronic daily intakes are estimated using age-specific assumptions. Table 6-31 presents the assumptions used in assessing exposure via dermal contact with soils and incidental ingestion of soils, respectively, for the average and maximum plausible case. This exposure analysis assumes that the chemicals and concentrations detected at a depth of one to two feet are representative of exposures at the depth to which future residents may be exposed. Conceivably, exposure to deeper soils could occur, particularly in the landfill area, if construction of the residences required extensive regrading and digging. Those potential exposures are not evaluated.

Exposure rates for the pathway involving dermal contact with soils are provided in Table 6-31 for four age periods. The exposure rates were based on a range of potential soil contact rates [0.5-1.5 mg soil/cm^2 for children (Schaum, 1984)] multiplied by a range of exposed body surface area estimates from EPA (1985b). For the first three age periods (2-7, 8-13, and 14-18 years), estimates of exposed surface areas were based on total body surface areas averaged across age group categories and across sexes and then multiplied by the fraction of total body area assumed to be exposed. For the average case, the 50th percentile total body surface area estimates were multiplied by the fraction of the total body area comprising the hands. For the maximum plausible case, the 95th percentile total body surface area estimates were multiplied by the fraction of the total body area comprising the hands and arms. Exposure rates for the last age period, 19 years and older, were based on mean surface areas by body part for adults averaged across sexes. The exposed surface areas for the average and maximum plausible cases were assumed to be hand and forearms, and the hands, forearms and lower legs, respectively.

ORIGINAL
(Red)

Table 6-31

Assumptions for Use in the Exposure Assessment for
Direct Contact with Soil by Persons at the Dorney Road Site

Dorney Road RI

Parameter	(Future-use Scenario) Average Exposure			Plausible Maximum Exposure			
Age of people exposed	2-7	8-13	14-18	2-7	8-13	14-18	19+
Frequency of exposure (E)	48	48	36	104	104	104	104
Duration of exposure (YR)	6	6	5	6	6	5	51
Average body weight over period of exposure (BW)	20	35	55	20	35	55	70
Incidental ingestion of contaminated soil (I)	100	50	50	500	250	100	100
Percent of PCBs and cPAHs absorbed from ingested soil (AI)	15%	15%	15%	45%	45%	45%	45%
Percent of non-PAH compounds absorbed from ingested soil (AI)	100%	100%	100%	100%	100%	100%	100%
Soil contact rate for use in dermal adsorption estimate (CD)	0.21	0.35	0.43	2.52	4.04	5.68	5.80
Percent of organic compound absorbed dermally from skin (ABS)							
- PAHs	0.2%		2%		0.2%	2%	
- PCBs	7%		7%		7%	7%	
- Other organic compounds	10%		10%		10%	10%	
Percent of inorganic compound absorbed dermally from skin	*	*	*	*	*	*	*
Lifetime (carcinogens) (YL)	70	70	70	70	70	70	70
Period of exposure (noncarcinogens) (YL)	6	6	5	6	6	5	51

* = negligible.

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ORIGINAL
(Red)

Dermal absorption was assumed to be as stated in the direct soil contact scenario discussed under current-use conditions. Similarly, absorption by the oral route was assumed to be 15% and 45% for PAHs and PCBs under average and maximum plausible case, respectively. The average and maximum plausible soil ingestion rates for children and adults are derived from LaGoy (1987) and are assumed to be 50 mg and 100 mg/day for average and maximum plausible cases. The assumptions used in this scenario are listed in Table 6-31.

The potential carcinogenic and noncarcinogenic risks associated with the estimated chronic daily exposures are shown in Tables 6-32. Extra lifetime cancer risk ranges from $9x10^{-7}$ to $9x10^{-5}$ for average and maximum plausible case assumptions. As with the current-use direct soil contact scenario, the risk is derived primarily from the PAHs, PCBs, and arsenic in surface soil. The hazard index in the plausible case exceeds a value of one due to the high lead content in the soil.

<u>Workers</u>. Exposure of future workers to indicator chemicals at the Dorney Road site is estimated. It is assumed that in the future, the site may be developed into a residential or industrial area. The exposure pathway considered is direct contact with soils, resulting in incidental ingestion and dermal absorption. Inhalation exposures are not evaluated quantitatively, but may occur if workers are exposed to volatile chemicals while digging in the landfill. Table 6-33 lists the assumptions used in estimating the exposures to workers from direct contact with surface and subsurface soils. The frequency of exposure is based on work occurring 5 days a week for 6 months of the year for the average case, and 5 days a week for 9 months of the year for the maximum plausible case. It is further assumed, that a worker may work at the site for 5 years under the average case, and for 10 years under the maximum plausible case. For the adult worker, the soil contact rate per exposed area is assumed to range from 0.5 mg/cm^2 to 1.5 mg/cm^2, and the exposed surface area of skin to range from 900 cm^2 to 2,900 cm^2.

Using these assumptions, the average and maximum plausible chronic daily intakes (CDIs) for future exposure of workers to surface and subsurface soils on-site are presented in Tables 6-34 and 6-35. The potential carcinogenic and noncarcinogenic risks associated with the estimated CDIs are also shown in Tables 6-34 and 6-35. The excess lifetime cancer risk is $2x10^{-7}$ under the average case and $2x10^{-5}$ under the maximum plausible case for workers exposed in the future to surface soils on-site. For workers exposed in the future to subsurface soils, the excess lifetime cancer risk is $4x10^{-8}$ under the average case and is $9x10^{-3}$ under the maximum plausible case. Exposure to chemicals exhibiting noncarcinogenic effects appears to present a low probability of adverse health effects based on the conditions for both average cases and the maximum plausible case for subsurface soil exposure, as the individual CDI:RfD ratios and the hazard indices for noncarcinogenic exposure are less than one. However, with the maximum plausible case assumptions for exposure to surface soils, the hazard index is greater than one, primarily due to the high lead content in the soil.

Table 6-32

Daily Intake and Risks Associated with Exposure to On-Site Surface Soil
by Persons Living at the Dorney Road Site

Future-Use Scenario

Dorney Road RI

A. Carcinogens

Chemical	Soil Concentrations (mg/kg) Geometric Mean	Soil Concentrations (mg/kg) Maximum	Quantity of Chemical Ingested and Absorbed (mg/kg/day) Average Case	Quantity of Chemical Ingested and Absorbed (mg/kg/day) Plausible Maximum Case	Quantity of Chemical Absorbed Dermally (mg/kg/day) Average Case	Quantity of Chemical Absorbed Dermally (mg/kg/day) Plausible Maximum Case	Chronic Daily[a] Intake Over 70-Year Lifetime (mg/kg/day) Average Case	Chronic Daily[a] Intake Over 70-Year Lifetime (mg/kg/day) Plausible Maximum Case	Potency[c] Factor $(mg/kg/day)^{-1}$	Extra Lifetime Cancer Risk Average Case	Extra Lifetime Cancer Risk Plausible Maximum Case
PAHs	1.13E+00	8.31E+00	1.33E-08	3.54E-06	6.55E-10	1.93E-06	1.40E-08	5.47E-06	1.15E+01	1.61E-07	6.29E-05
PCB	NA	6.50E-01	NE	2.77E-07	NE	5.29E-07	NE	8.06E-07	7.00E+00	NE	5.64E-06
Arsenic	5.83E+00	1.60E+01	4.60E-07	1.52E-05	b	b	4.60E-07	1.52E-05	1.50E+00	6.90E-07	2.28E-05
Benzene	2.26E-03	1.00E-03	1.78E-10	9.48E-10	6.46E-11	1.16E-09	2.44E-10	2.11E-09	5.20E-02	1.27E-11	1.10E-10
Chloroform	2.85E-03	7.20E-02	2.25E-10	6.83E-08	8.15E-11	8.37E-08	3.08E-10	1.52E-07	8.10E-02	2.49E-11	1.23E-08
Bis(ethylhexyl) phthalate	2.06E-01	2.00E+01	1.63E-08	1.90E-05	5.89E-09	2.32E-05	2.22E-08	4.22E-05	8.30E-03	1.84E-10	3.50E-07
Dieldrin	9.38E-03	8.80E-02	7.64E-10	8.37E-08	2.68E-10	1.00E-07	1.03E-09	1.84E-07	3.00E+01	3.43E-11	6.13E-09
TOTAL										8.51E-07	9.17E-05

Table 6-32 (continued)

Daily Intake and Risks Associated with Exposure to On-Site Surface Soil
by Persons Living at the Dorney Road Site

Future-Use Scenario

Dorney Road RI

B. Noncarcinogens

Chemical	Soil Concentrations (mg/day)		Quantity of Chemical Ingested and Absorbed (mg/kg/day)		Quantity of Chemical Absorbed Dermally (mg/kg/day)		Chronic Daily Intake Over Exposure Period (mg/kg/day)[a]		Reference Dose (RfD) (mg/kg/day)[c]	CDI:Rfd Risk	
	Geometric Mean	Maximum	Average Case	Plausible Maximum Case	Average Case	Plausible Maximum Case	Average Case	Plausible Maximum Case		Average Case	Plausible Maximum Case
Bis(ethylhexyl) phthalate	2.06E-01	2.00E+01	1.93E-07	1.94E-04	7.14E-08	2.00E-04	2.64E-07	3.94E-04	2.00E-02	1.32E-05	1.97E-02
Diethyl phthalate	1.64E-01	3.80E-01	1.53E-07	3.69E-06	5.69E-08	3.80E-06	2.10E-07	7.49E-06	8.00E-01	2.63E-07	9.37E-06
Phenol	1.72E-01	4.10E-01	1.61E-07	3.98E-06	5.96E-08	4.10E-06	2.20E-07	8.08E-06	4.00E-02	5.51E-06	2.02E-04
4-Methyl pentanone	NA	4.70E-02	NE	4.56E-07	NE	4.70E-07	NE	9.27E-07	5.00E-02	NE	1.85E-05
Chlorobenzene	2.81E-03	2.40E-02	2.63E-09	2.33E-07	9.74E-10	2.40E-07	3.60E-09	4.73E-07	2.70E-02	1.33E-07	1.75E-05
Ethylbenzene	2.82E-03	4.10E-02	2.64E-09	3.98E-07	9.78E-10	4.10E-07	3.62E-09	8.08E-07	1.00E-01	3.62E-08	8.08E-06
4-Methylphenol	2.23E-01	3.40E+00	2.08E-07	3.30E-05	7.72E-08	3.40E-05	2.86E-07	6.70E-05	5.00E-02	5.71E-06	1.34E-03
Beryllium	2.76E+00	6.30E+00	2.58E-06	6.12E-05	b	b	2.58E-06	6.12E-05	5.00E-03	5.16E-04	1.22E-02
Chromium	2.32E+01	1.58E+03	2.17E-05	1.53E-02	b	b	2.17E-05	1.53E-02	5.00E-03	4.33E-03	3.07E+00
Copper	2.40E+01	2.16E+02	2.24E-05	2.10E-03	b	b	2.24E-05	2.10E-03	3.70E-02	6.06E-04	5.67E-02
Lead	1.58E+02	9.06E+04	1.48E-04	8.80E-01	b	b	1.48E-04	8.80E-01	6.00E-04	2.47E-01	1.47E+03
Mercury	1.30E-01	2.30E-01	1.22E-07	2.23E-06	b	b	1.22E-07	2.23E-06	1.40E-03	8.68E-05	1.60E-03
Nickel	5.51E+01	3.58E+03	5.15E-05	3.48E-02	b	b	5.15E-05	3.48E-02	2.00E-02	2.57E-03	1.74E+00
Thallium	1.77E+00	3.70E+00	1.65E-06	3.46E-06	b	b	1.65E-06	3.46E-06	4.00E-04	4.13E-03	8.65E-03
Zinc	1.42E+02	4.72E+02	1.32E-04	4.58E-03	b	b	1.32E-04	4.58E-03	2.10E-01	6.30E-04	2.18E-02
TOTAL										2.59E-01	1.47E+03

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ORIGINA (Red

Table 6-32 (continued)

Daily Intake and Risks Associated with Exposure to On-Site Surface Soil
by Persons Living at the Dorney Road Site

Future-Use Scenario

Dorney Road RI

[a] Chronic daily intake (averaged over a 70-year lifetime for carcinogens, averaged over the exposure period for noncarcinogens) is the sum of the daily intake from the ingestion pathway and the dermal pathway. Calculated as follows:

Ingestion: $CDI = \frac{(Cs)(I)(AI)(E)(Yr)(X)}{(BW)(DY)(YL)}$ Dermal absorption: $CDI = \frac{(Cs)(CD)(E)(Yr)(Z)(Abs)}{(BW)(DY)(YL)}$

where Cs = concentration in soil; geometric means used for average case and maximum concentrations used for maximum plausible case. Definitions and values for these parameters are found in Section 6.4.4.2 and Table 6-31.

[b] Dermal absorption could not be evaluated for metals.

[c] Potency factors and reference doses are listed in Table 6-17.

NA - not applicable. Only detected in one sample, and use of one-half of the detection limit in calculating the mean results in a mean concentration that is less than the detection limit.

NE - not evaluated.

ORIGINAL (Red)

Table 6-33

Assumptions for Use in the Exposure Assessment
for Direct Contact with Surface and Subsurface Soil
by Workers at the Dorney Road Site

Dorney Road RI

(Future-use Scenario)

Parameter	Average	Plausible
Age of people exposed	19+	19+
Frequency of exposure (E)	130	195
Duration of exposure (YR)	5	10
Average body weight over period of exposure (BW)	70	70
Incidental ingestion of contaminated soil (I)	50	100
Percent of PCBs and PAHs absorbed from ingested soil (AI)	15%	45%
Percent of non-PAH compounds absorbed from ingested soil (AI)	100%	100%
Soil contact rate for use in dermal adsorption estimate (CD)	0.45	4.35
Percent of organic compound absorbed dermally from skin (ABS)		
- PAHs	0.2%	2%
- PCBs	7%	7%
- Other organic compounds	10%	10%
Percent of inorganic compound absorbed dermally from skin	negligible	negligible
Lifetime (carcinogens) (YL)	70	70
Period of exposure (non-carcinogens) (YL)	5	10

Table 6-34

Daily Intake and Risks Associated with Exposure
to On-Site Surface Soil by Workers at the Dorney Road Site

Future-Use Scenario

Dorney Road RI

A. Carcinogens

Chemical	Soil Concentrations (mg/kg) Geometric Mean	Soil Concentrations (mg/kg) Maximum	Quantity of Chemical Ingested and Absorbed (mg/kg/day) Average Case	Quantity of Chemical Ingested and Absorbed (mg/kg/day) Plausible Maximum Case	Quantity of Chemical Absorbed Dermally (mg/kg/day) Average Case	Quantity of Chemical Absorbed Dermally (mg/kg/day) Plausible Maximum Case	Chronic Daily[a] Intake Over 70-Year Lifetime (mg/kg/day) Average Case	Chronic Daily[a] Intake Over 70-Year Lifetime (mg/kg/day) Plausible Maximum Case	Potency[c] Factor $(mg/kg/day)^{-1}$	Extra Lifetime Cancer Risk Average Case	Extra Lifetime Cancer Risk Plausible Maximum Case
PAHs	1.13E+00	8.31E+00	3.08E-09	4.07E-07	3.62E-10	7.87E-07	3.45E-09	1.19E-06	1.15E+01	3.96E-08	1.37E-05
PCB	NA	6.50E-01	NE	3.19E-08	NE	2.15E-07	NE	2.47E-07	7.00E+00	NE	1.73E-06
Arsenic	5.83E+00	1.60E+01	1.09E-07	1.74E-06	b	b	1.09E-07	1.74E-06	1.50E+00	1.64E-07	2.62E-06
Benzene	2.26E-03	1.00E-03	4.23E-11	1.09E-10	3.62E-11	4.73E-10	7.84E-11	5.82E-10	5.20E-02	4.08E-12	3.03E-11
Chloroform	2.85E-03	7.20E-02	5.33E-11	7.85E-09	4.56E-11	3.41E-08	9.89E-11	4.19E-08	8.10E-02	8.01E-12	3.40E-09
Bis(ethylhexyl) phthalate	2.06E-01	2.00E+01	3.85E-09	2.18E-06	3.30E-09	9.47E-06	7.15E-09	1.16E-05	8.30E-03	5.93E-11	9.67E-08
Dieldrin	9.38E-03	8.80E-02	1.75E-10	9.59E-09	1.50E-10	4.17E-08	3.25E-10	5.12E-08	3.00E+01	9.76E-09	1.54E-06
TOTAL										2.13E-07	1.97E-05

Table 6-34 (continued)

Daily Intake and Risks Associated with Exposure
to On-Site Surface Soil by Workers at the Dorney Road Site

Future-Use Scenario

Dorney Road RI

B. Noncarcinogens

Chemical	Soil Concentrations (mg/day)		Quantity of Chemical Ingested and Absorbed (mg/kg/day)		Quantity of Chemical Absorbed Dermally (mg/kg/day)		Chronic Daily Intake Over Exposure Period (mg/kg/day)[a]		Reference Dose (RfD) (mg/kg/day)[c]	CDI:Rfd	Risk
	Geometric Mean	Maximum	Average Case	Plausible Maximum Case	Average Case	Plausible Maximum Case	Average Case	Plausible Maximum Case		Average Case	Plausible Maximum Case
Bis(ethylhexyl) phthalate	2.06E-01	2.00E+01	5.23E-08	1.53E-05	4.72E-08	6.64E-05	9.95E-08	8.17E-05	2.00E-02	4.98E-06	4.08E-03
Di-N-butyl phthalate	2.14E-01	2.00E+00	5.44E-08	1.53E-06	4.90E-08	6.64E-06	1.03E-07	8.17E-06	1.30E+01	7.95E-09	6.28E-07
Phenol	1.72E-01	4.10E-01	4.37E-08	3.13E-07	3.94E-08	1.36E-06	8.30E-08	1.67E-06	4.00E-02	2.08E-06	4.15E-05
4-Methyl pentanone	NA	4.70E-02	NE	3.59E-08	NE	1.56E-07	NE	1.92E-07	5.00E-02	NE	3.84E-06
Chlorobenzene	2.81E-03	2.40E-02	7.14E-10	1.83E-08	6.43E-10	7.97E-08	1.36E-09	9.80E-08	2.70E-02	5.08E-08	3.63E-06
Ethylbenzene	2.82E-03	4.10E-02	7.16E-10	3.13E-08	6.46E-10	1.36E-07	1.36E-09	1.67E-07	1.00E-01	1.36E-08	1.67E-06
4-Methylphenol	2.23E-01	3.40E+00	5.66E-08	2.59E-06	5.10E-08	1.13E-05	1.08E-07	1.39E-05	5.00E-02	2.15E-06	2.78E-04
Naphthalene	1.85E+02	1.22E+03	4.70E-05	9.27E-04	4.24E-05	4.03E-03	8.95E-05	4.96E-03	4.10E-02	2.18E-03	1.21E-01
Beryllium	2.76E+00	6.30E+00	7.01E-07	4.81E-06	b	b	7.01E-07	4.81E-06	5.00E-03	1.40E-04	9.61E-04
Chromium	2.32E+01	1.58E+03	5.88E-06	1.21E-03	b	b	5.88E-06	1.21E-03	5.00E-03	1.18E-03	2.41E-01
Copper	2.40E+01	2.16E+02	6.10E-06	1.65E-04	b	b	6.10E-06	1.65E-04	3.70E-02	1.65E-04	4.45E-03
Lead	1.58E+02	9.06E+04	4.02E-05	6.91E-02	b	b	4.02E-05	6.91E-02	6.00E-04	6.70E-02	1.15E+02
Mercury	1.30E-01	2.30E-01	3.30E-08	1.75E-07	b	b	3.30E-08	1.75E-07	1.40E-03	2.36E-05	1.25E-04
Nickel	5.51E+01	3.58E+03	1.40E-05	2.73E-03	b	b	1.40E-05	2.73E-03	2.00E-02	6.99E-04	1.37E-01
Thallium	1.77E+00	3.70E+00	4.50E-07	2.82E-06	b	b	4.50E-07	2.82E-06	4.00E-04	1.13E-03	7.05E-03
Zinc	1.42E+02	4.72E+02	3.60E-05	3.60E-04	b	b	3.60E-05	3.60E-04	2.10E-01	1.71E-04	1.71E-03
TOTAL										7.26E-02	1.16E+02

ORIGINAL (Red)

Table 6-34 (continued)

Daily Intake and Risks Associated with Exposure
to On-Site Surface Soil by Workers at the Dorney Road Site

Future-Use Scenario

Dorney Road RI

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[a] Chronic daily intake (averaged over a 70-year lifetime for carcinogens, averaged over the exposure period for noncarcinogens) is the sum of the daily intake from the ingestion pathway and the dermal pathway. Calculated as follows:

Ingestion: $CDI = \frac{(Cs)(I)(AI)(E)(Yr)(X)}{(BW)(DY)(YL)}$ Dermal absorption: $CDI = \frac{(Cs)(CD)(E)(Yr)(Z)(Abs)}{(BW)(DY)(YL)}$

where Cs = concentration in soil; geometric means used for average case and maximum concentrations used for maximum plausible case. Definitions and values for these parameters are found in Section 6.4.4.2 and Table 6-33.

[b] Dermal absorption could not be evaluated for metals.

[c] Potency factors and reference doses are listed in Table 6-17.

NA - not applicable. Only detected in one sample, and use of one-half of the detection limit in calculating the mean results in a mean concentration that is less than the detection limit.

NE - not evaluated.

ORIGINAL (Red)

Table 6-35

Daily Intake and Risks Associated with Exposure
to On-Site Subsurface Soil by Workers at the Dorney Road Site

Future-Use Scenario

Dorney Road RI

A. Carcinogens

Chemical	Soil Concentrations (mg/kg) Geometric Mean	Soil Concentrations (mg/kg) Maximum	Quantity of Chemical Ingested and Absorbed (mg/kg/day) Average Case	Quantity of Chemical Ingested and Absorbed (mg/kg/day) Plausible Maximum Case	Quantity of Chemical Absorbed Dermally (mg/kg/day) Average Case	Quantity of Chemical Absorbed Dermally (mg/kg/day) Plausible Maximum Case	Chronic Daily[a] Intake Over 70-Year Lifetime (mg/kg/day) Average Case	Chronic Daily[a] Intake Over 70-Year Lifetime (mg/kg/day) Plausible Maximum Case	Potency[b] Factor $(mg/kg/day)^{-1}$	Extra Lifetime Cancer Risk Average Case	Extra Lifetime Cancer Risk Plausible Maximum Case
PAHs	1.20E+00	5.33E+03	3.28E-09	2.61E-04	3.04E-10	5.06E-04	3.66E-09	7.67E-04	1.15E+01	4.21E-08	8.82E-03
Benzene	NA	2.00E+00	NE	2.18E-07	NE	9.49E-07	NE	1.17E-06	5.20E-02	NE	6.07E-08
Chloroform	3.08E-03	6.00E+00	5.76E-11	6.54E-07	4.93E-11	2.85E-06	1.07E-10	3.50E-06	8.10E-02	8.66E-12	2.84E-07
1,2-Dichloro-ethylene	NA	1.90E+01	NE	2.07E-06	NE	9.01E-06	NE	1.11E-05	5.80E-01	NE	6.43E-06
Tetrachloro-ethylene	NA	5.00E+00	NE	5.45E-07	NE	2.37E-06	NE	2.92E-06	5.10E-02	NE	1.49E-07
TOTAL										4.21E-08	8.83E-03

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Table 6-35 (continued)

Daily Intake and Risks Associated with Exposure
to On-Site Subsurface Soil by Workers at the Dorney Road Site

Future-Use Scenario

Dorney Road RI

B. Noncarcinogens

Chemical	Soil Concentrations (mg/kg) Geometric Mean	Soil Concentrations (mg/kg) Maximum	Quantity of Chemical Ingested and Absorbed (mg/kg/day) Average Case	Quantity of Chemical Ingested and Absorbed (mg/kg/day) Plausible Maximum Case	Quantity of Chemical Absorbed Dermally (mg/kg/day) Average Case	Quantity of Chemical Absorbed Dermally (mg/kg/day) Plausible Maximum Case	Chronic Daily Intake Over Exposure Period[a] (mg/kg/day) Average Case	Chronic Daily Intake Over Exposure Period[a] (mg/kg/day) Plausible Maximum Case	Reference Dose (RfD)[b] (mg/kg/day)	CDI:Rfd Risk Average Case	CDI:Rfd Risk Plausible Maximum Case
Diethyl-phthalate	1.79E-01	1.00E+00	4.54E-08	7.63E-07	4.09E-08	3.32E-06	8.64E-08	4.08E-06	8.00E-01	1.08E-07	5.10E-06
Phenol	2.55E-01	1.10E+00	6.47E-08	8.39E-07	5.83E-08	3.65E-06	1.23E-07	4.49E-06	4.00E-02	3.08E-06	1.12E-04
Ethylbenzene	1.64E-02	2.00E-01	4.17E-09	1.53E-07	3.76E-09	6.64E-07	7.92E-09	8.17E-07	1.00E-01	7.92E-08	8.17E-06
Toluene	8.15E-02	1.90E-01	2.07E-08	1.45E-07	1.87E-08	6.31E-07	3.94E-08	7.76E-07	3.00E-01	1.31E-07	2.59E-06
Xylenes (total)	4.95E-02	9.30E-01	1.26E-08	7.10E-07	1.13E-08	3.09E-06	2.39E-08	3.80E-06	2.00E+00	1.21E-08	1.90E-06 Di-
N-butyl-phthalate	2.27E-01	8.30E-01	5.77E-08	6.33E-07	5.20E-08	2.76E-06	1.10E-07	3.39E-06	1.00E-01	1.10E-06	3.39E-05
TOTAL										4.50E-06	1.64E-04

000271

ORIGINAL (Red)

Table 6-35 (continued)

Daily Intake and Risks Associated with Exposure
to On-Site Subsurface Soil by Workers at the Dorney Road Site

Future-Use Scenario

Dorney Road RI

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[a]Chronic daily intake (averaged over a 70-year lifetime for carcinogens, averaged over the exposure period for noncarcinogens) is the sum of the daily intake from the ingestion pathway and the dermal pathway. Calculated as follows:

Ingestion: $CDI = \frac{(Cs)(I)(AI)(E)(Yr)(X)}{(BW)(DY)(YL)}$ Dermal absorption: $CDI = \frac{(Cs)(CD)(E)(Yr)(Z)(Abs)}{(BW)(DY)(YL)}$

where Cs = concentration in soil; geometric means used for average case and maximum concentrations used for maximum plausible case. Definitions and values for these parameters are found in Section 6.4.4.2 and Table 6-33.

[b]Potency factors and reference doses are listed in Table 6-17.

NA - not applicable. Only detected in one sample, and use of one-half of the detection limit in calculating the mean results in a mean concentration that is less than the detection limit.

NE - not evaluated.

ORIGINAL (Red)

Future Use of Groundwater

Future-use exposure via groundwater from on-site wells and off-site shallow and deep wells is estimated. It is assumed that the Dorney Road Site may be developed for residential use and that there would be wells on-site for residential use. It is also assumed that other areas off-site may be developed and that such development may involve shallow or deep groundwater wells.

Estimation of future-use exposure from these wells would involve estimation of leaching of soil contaminants to groundwater by estimating downward migration of contaminants using a steady-state dispersion model. The model would predict future concentrations at bedrock and dilution factors would then be applied to account for attenuation and dispersion of contaminants during downward migration into groundwater. In the absence of this groundwater modeling data, it is assumed that in the future, contaminant levels will not exceed present levels as indicated by on-site and off-site, both shallow and deep, groundwater samples.

Assumptions of water ingestion and average and maximum plausible cases are as stated previously (Section 6.4.4.1). Potential risks associated with other uses of well water, i.e. cooking and watering of lawns or gardens, have not been addressed. The average and maximum plausible chronic daily intakes (CDIs) for exposure to contaminants from groundwater under future-use conditions for on-site wells are presented in Table 6-36, while those for off-site shallow and off-site deep wells are presented in Tables 6-37 and 6-38, respectively.

The potential carcinogenic and noncarcinogenic risks associated with the estimated CDIs for drinking water and showering combined are also shown in Tables 6-36, 6-37 and 6-38. From drinking and showering with groundwater from future on-site wells, the excess lifetime cancer risk is $1x10^{-3}$ under the average case and $1x10^{-2}$ under the maximum plausible case. From drinking and showering with groundwater from future off-site shallow wells, the excess lifetime cancer risk is $9x10^{-4}$ under the average case and $4x10^{-3}$ under the maximum plausible case. From drinking and showering with groundwater from future off-site deep wells, the excess lifetime cancer risk is $1x10^{-4}$ under the average case and $3x10^{-4}$ under the maximum plausible case.

Recreational Users. Exposure of future recreational users of the Dorney Road Landfill site to soil contaminants also was not assessed quantitatively. Assuming the reported soil concentrations are representative of the chemical concentrations at the depth to which future recreational users would be exposed, exposure and risks to these individuals would likely be less than those to future residents because exposure durations and frequencies are likely to be much less. Potential exposures of future recreational users to soil contaminants at greater depths cannot be evaluated.

Table 6-36

Daily Intake and Risks Associated with Exposure to Groundwater
On Site at the Dorney Road Landfill Site

Future-Use Scenario

Dorney Road RI

A. Carcinogens

Chemical	Groundwater Concentration (ug/l)		Daily Intake Average Case (mg/kg/day)		Daily Intake Plausible Maximum Case (mg/kg/day)		Chronic Daily Intake[a]		Potency[b] Factor $(mg/kg/day)^{-1}$	Extra Cancer Risk	
	Geometric Mean	Maximum	Drinking Water	Shower	Drinking Water	Shower	Average Case	Plausible Case		Average Case	Maximum Plausible Case
Benzene	5.16	14	1.47E-04	1.55E-04	4.00E-04	4.22E-04	3.02E-04	8.22E-04	5.20E-02	1.57E-05	4.27E-05
Arsenic	12.9	140	3.68E-04	NE	4.00E-03	NE	3.68E-04	4.00E-03	1.50E+00	5.52E-04	6.00E-03
Vinyl chloride	6.23	25	1.78E-04	2.08E-04	7.14E-04	8.34E-04	3.86E-04	1.55E-03	2.30E+00	8.87E-04	3.56E-03
Bis(2-ethylhexyl)-phthalate	13.80	40	3.94E-04	NE	1.14E-03	NE	3.94E-04	1.14E-03	8.30E-03	3.27E-06	9.46E-06
TOTAL										1.46E-03	9.61E-03

000274

Table 6-36

Daily Intake and Risks Associated with Exposure to Groundwater
On Site at the Dorney Road Landfill Site

Future-Use Scenario

Dorney Road RI

A. Carcinogens

Chemical	Groundwater Concentration (ug/l) Geometric Mean	Groundwater Concentration (ug/l) Maximum	Daily Intake Average Case (mg/kg/day) Drinking Water	Daily Intake Average Case (mg/kg/day) Shower	Daily Intake Plausible Maximum Case (mg/kg/day) Drinking Water	Daily Intake Plausible Maximum Case (mg/kg/day) Shower	Chronic Daily Intake[a] Average Case	Chronic Daily Intake[a] Plausible Case	Potency[b] Factor $(mg/kg/day)^{-1}$	Extra Cancer Risk Average Case	Extra Cancer Risk Maximum Plausible Case
Benzene	5.16	14	1.47E-04	1.55E-04	4.00E-04	4.22E-04	3.02E-04	8.22E-04	5.20E-02	1.57E-05	4.27E-05
Arsenic	12.9	140	3.68E-04	NE	4.00E-03	NE	3.68E-04	4.00E-03	1.50E+00	5.52E-04	6.00E-03
Vinyl chloride	6.23	25	1.78E-04	2.08E-04	7.14E-04	8.34E-04	3.86E-04	1.55E-03	2.30E+00	8.87E-04	3.56E-03
Bis(2-ethylhexyl)-phthalate	13.80	40	3.94E-04	NE	1.14E-03	NE	3.94E-04	1.14E-03	8.30E-03	3.27E-06	9.46E-06
TOTAL										1.46E-03	9.61E-03

000275

ORIGINAL (Red)

Table 6-36 (continued)

Daily Intake and Risks Associated with Exposure to Groundwater
On Site at the Dorney Road Landfill Site

Future-Use Scenario

Dorney Road RI

B. Noncarcinogens

Chemical	Groundwater Concentration (ug/l)		Daily Intake Average Case (mg/kg/day)		Daily Intake Plausible Maximum Case (mg/kg/day)		Chronic Daily Intake[a]		Reference Dose (Rfd)[b] (mg/kg/day)	CDI: RfD Risk	
	Geometric Mean	Maximum	Drinking Water	Shower	Drinking Water	Shower	Average Case	Plausible Case		Average Case	Maximum Plausible Case
1,2-Dichloroethene	11.59	79	3.31E-04	3.25E-04	2.26E-03	2.22E-03	6.56E-04	4.48E-03	5.80E-01	7.29E-02	4.98E-01
Styrene	NA	43	NE	NE	1.23E-03	NE	NE	1.23E-03	2.00E-01	NE	6.15E-03
Phenol	32.60	3200	1.30E-03	NE	1.28E-01	NE	1.30E-03	1.28E-01	4.00E-02	3.25E-02	3.20E+00
Ethylbenzene	107.9	160	3.08E-03	2.92E-03	4.57E-03	4.33E-03	6.00E-03	8.90E-03	1.00E-01	6.00E-02	8.90E-02
Xylenes	305.70	530	8.73E-03	8.29E-03	1.51E-02	1.44E-02	1.70E-02	2.95E-02	2.00E+00	8.50E-03	1.48E-02
Bis(2-ethylhexyl)-phthalate	13.80	40	3.94E-04	NE	1.14E-03	NE	3.94E-04	1.14E-03	2.00E-02	1.97E-02	5.71E-02
Diethylphthalate	8.43	20	2.40E-04	NE	5.71E-04	NE	2.40E-04	5.71E-04	8.00E-01	3.00E-04	7.14E-04
Barium	767.7	3480	2.19E-02	NE	9.94E-02	NE	2.19E-02	9.94E-02	5.10E-02	4.29E-01	1.95E+00
Beryllium	4.6	22	1.31E-04	NE	6.28E-04	NE	1.31E-04	6.28E-04	5.00E-03	2.62E-02	1.26E-01
Cadmium	5.8	19	1.65E-04	NE	5.42E-04	NE	1.65E-04	5.42E-04	5.00E-04	3.30E-01	1.08E-01
Chromium	38.0	72	1.09E-03	NE	2.06E-03	NE	1.09E-03	2.06E-03	5.00E-03	2.17E-01	4.11E-01
Copper	50.7	218	1.45E-03	NE	6.23E-03	NE	1.45E-03	6.23E-03	3.70E-02	3.91E-02	1.68E-01
Lead	627.1	11,900	1.79E-02	NE	3.40E-01	NE	1.79E-02	3.40E-01	6.00E-04	2.98E+01	5.67E+02
Mercury	0.27	0.64	7.00E-06	NE	1.80E-05	NE	7.00E-06	1.00E-05	1.40E-03	5.00E-03	7.14E-03
Nickel	684	3540	1.95E-02	NE	1.01E-01	NE	1.95E-02	1.01E-01	2.00E-02	9.75E-01	5.05E+00
Zinc	4165	37,700	1.19E-01	NE	1.08E+00	NE	1.19E-01	1.08E+00	2.10E-01	5.67E-01	5.13E+00
TOTAL										3.22E+01	[illegible]E+02

ORIGINAL (Red)

Table 6-37

Daily Intake and Risks Associated with Exposure to Groundwater
Shallow Wells at the Dorney Road Landfill Site

Future-Use Scenario

Dorney Road RI

A. Carcinogens

Chemical	Groundwater Concentration (ug/l) Geometric Mean	Groundwater Concentration (ug/l) Maximum	Daily Intake Average Case (mg/kg/day) Drinking Water	Daily Intake Average Case (mg/kg/day) Shower	Daily Intake Plausible Maximum Case (mg/kg/day) Drinking Water	Daily Intake Plausible Maximum Case (mg/kg/day) Shower	Chronic Daily Intake[a] Average Case	Chronic Daily Intake[a] Plausible Case	Potency Factor[b] $(mg/kg/day)^{-1}$	Extra Cancer Risk Average Case	Extra Cancer Risk Maximum Plausible Case
Benzene	NA	6	NE	NE	1.71E-04	1.81E-04	NE	3.52E-04	5.20E-02	NE	1.83E-05
1,1-Dichloroethane	4.26	22	1.21E-04	1.17E-04	6.28E-04	6.02E-04	2.38E-04	1.23E-03	9.10E-02	2.17E-05	1.12E-04
1,2-Dichloroethane	NA	3	NE	NE	8.50E-05	7.21E-05	NE	1.57E-04	9.10E-02	NE	1.43E-05
Arsenic	5.05	46	1.44E-04	NE	1.31E-03	NE	1.44E-04	1.31E-03	1.50E+00	2.16E-04	1.97E-03
Tetrachloroethylene	3.64	37	1.04E-04	8.47E-05	1.06E-03	8.61E-04	1.89E-04	1.92E-03	5.10E-02	9.62E-06	9.78E-05
Vinyl chloride	4.54	14	1.29E-04	1.51E-04	4.00E-04	4.67E-04	2.80E-04	8.67E-04	2.30E+00	6.45E-04	1.99E-03
Bis(2-ethylhexyl)-phthalate	2.92	9	8.30E-05	0.00E+00	2.57E-04	NE	8.30E-05	2.57E-04	8.30E-03	6.89E-06	2.13E-06
Trichloroethylene	3.55	51	1.01E-04	8.94E-05	1.46E-03	1.28E-03	1.90E-04	2.74E-03	1.10E-02	2.09E-06	3.02E-05
TOTAL										9.02E-04	4.23E-03

000277

ORIGINAL

Table 6-37 (continued)

Daily Intake and Risks Associated with Exposure to Groundwater
Shallow Wells at the Dorney Road Landfill Site

Future-Use Scenario

Dorney Road RI

B. Noncarcinogens

Chemical	Groundwater Concentration (ug/l) Geometric Mean	Maximum	Daily Intake Average Case (mg/kg/day) Drinking Water	Shower	Daily Intake Plausible Maximum Case (mg/kg/day) Drinking Water	Shower	Chronic Daily Intake[a] Average Case	Plausible Case	Reference Dose (RfD)[b] (mg/kg/day)	CDI: RfD Risk Average Case	Maximum Plausible Case
1,2-Dichloroethene	5.1	180	1.45E-04	1.43E-04	5.14E-03	5.05E-03	2.88E-04	1.02E-02	5.80E-01	4.97E-04	1.76E-02
1,1,1-Trichloroethane	NA	2	NE	NE	5.70E-05	5.04E-05	NE	1.07E-04	9.00E-02	NE	1.19E-03
Bis(2-ethylhexyl)-phthalate	2.92	9	8.30E-05	NE	2.57E-04	NE	8.30E-05	2.57E-04	2.00E-02	4.15E-03	1.29E-02
Phenol	NA	25	NE	NE	7.14E-04	1.76E-06	NE	7.16E-04	4.00E-02	NE	1.79E-02
Toluene	NA	1	NE	NE	2.80E-05	2.85E-05	NE	5.65E-05	3.00E-01	NE	1.88E-04
Beryllium	3.89	39.5	1.11E-04	NE	1.13E-03	NE	1.11E-04	1.13E-03	5.00E-03	2.22E-02	2.26E-01
Cadmium	3.35	14.7	9.50E-05	NE	4.20E-04	NE	9.50E-05	4.20E-04	5.00E-04	1.90E-01	8.40E-01
Lead	14.5	424.5	4.14E-04	NE	1.21E-02	NE	4.14E-04	1.21E-02	6.00E-04	6.90E-01	2.02E+01
Manganese	723.9	19,090	NE	NE	5.45E-01	NE	NE	5.45E-01	2.20E-01	NE	2.48E+00
Mercury	0.70	1.07	2.00E-05	NE	3.00E-05	NE	2.00E-05	3.00E-05	1.40E-03	1.43E-02	2.00E-03
Thallium	6.02	33	9.43E-04	NE	9.22E-04	NE	9.43E-04	9.22E-04	4.00E-04	2.36E+00	2.31E+00
Zinc	210.2	1008.5	6.00E-03	NE	2.88E-02	NE	6.00E-03	2.88E-02	2.10E-01	2.86E-02	1.37E-01
TOTAL										3.31E+00	2.62E+01

Table 6-37 (continued)

Daily Intake and Risks Associated with Exposure to Groundwater
Shallow Wells at the Dorney Road Landfill Site

Future-Use Scenario

Dorney Road RI

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[a] Chronic daily intake (averaged over a 70-year lifetime for carcinogens, averaged over the exposure period for noncarcinogens) is the sum of the daily intake from the ingestion of drinking water pathway and from inhalation of volatilized chemicals during showering. Drinking water intake calculated as follows:

$$CDI = \frac{Cw\ (2\ l/day)(1\ mg/1000\ ug)}{70\ kg}$$

where Cw = concentration in residential wells; geometric means used for average case and maximum concentrations used for maximum plausible case for both drinking water and showering. Inhalation exposure estimated according to the method of Foster and Chrostowski.

[b] Potency factors and reference doses are listed in Table 6-17.

NA - not applicable. Only detected in one sample, and use of one-half of the detection limit in calculating the mean results in a mean concentration that is less than the detection limit.

NE - not evaluated.

Table 6-38

Daily Intake and Risks Associated with Exposure to Groundwater
Off-Site Deep Wells at the Dorney Road Landfill Site

Future-Use Scenario

Dorney Road RI

A. Carcinogens

Chemical	Groundwater Concentration (ug/l)		Daily Intake Average Case (mg/kg/day)		Daily Intake Plausible Maximum Case (mg/kg/day)		Chronic Daily Intake[a]		Potency Factor[b]	Extra Cancer Risk	
	Geometric Mean	Maximum	Drinking Water	Shower	Drinking Water	Shower	Average Case	Plausible Case	$(mg/kg/day)^{-1}$	Average Case	Maximum Plausible Case
Benzene	NA	6	NE	NE	1.71E-04	1.81E-04	NE	3.52E-04	5.20E-02	NE	1.83E-05
Arsenic	2.90	1.9	8.20E-05	NE	5.40E-05	NE	8.20E-05	5.40E-05	1.50E+00	1.23E-04	8.10E-05
1,1-Dichloroethane	2.65	4	7.50E-05	7.25E-05	1.14E-04	1.09E-04	1.48E-04	2.23E-04	9.10E-02	1.35E-05	2.03E-05
Trichloroethylene	NA	15	NE	NE	4.28E-04	3.78E-04	NE	8.06E-04	1.10E-02	NE	8.86E-06
Vinyl chloride	NA	1	NE	NE	2.80E-05	3.34E-05	NE	6.14E-05	2.30E+00	NE	1.41E-04
Tetrachloroethylene	2.73	9	7.80E-05	6.35E-05	2.57E-04	2.09E-04	1.42E-04	4.66E-04	5.10E-02	7.22E-06	2.38E-05
Bis(2-ethylhexyl)-phthalate	12.65	33	3.61E-04	NE	9.42E-04	NE	3.61E-04	9.42E-04	8.30E-03	3.00E-06	7.82E-06
TOTAL										1.47E-04	3.01E-04

Table 6-38 (continued)

Daily Intake and Risks Associated with Exposure to Groundwater
Off-Site Deep Wells at the Dorney Road Landfill Site

Future-Use Scenario

Dorney Road RI

B. Noncarcinogens

Chemical	Groundwater Concentration (ug/l)		Daily Intake Average Case (mg/kg/day)		Daily Intake Plausible Maximum Case (mg/kg/day)		Chronic Daily Intake[a]		Reference[b]	CDI: RfD Risk	
	Geometric Mean	Maximum	Drinking Water	Shower	Drinking Water	Shower	Average Case	Plausible Case	Dose (Rfd) (mg/kg/day)	Average Case	Maximum Plausible Case
1,2-Dichloroethene	4.0	41	1.14E-04	1.12E-04	1.17E-03	1.15E-03	2.26E-04	2.32E-03	5.80E-01	3.90E-04	4.00E-03
Toluene	6.59	43	1.88E-04	1.88E-04	1.23E-03	1.23E-03	3.76E-04	2.45E-03	3.00E-01	1.25E-03	8.18E-03
1,1,1-Trichloroethane	NA	1	NE	NE	2.80E-05	2.52E-05	NE	5.32E-05	9.00E-02	NE	5.91E-04
Bis(2-ethylhexyl)-phthalate	12.65	33	3.61E-04	NE	9.42E-04	NE	3.61E-04	9.42E-04	2.00E-02	1.81E-02	4.71E-02
Beryllium	NA	2.6	NE	NE	7.40E-05	NE	NE	7.40E-05	5.00E-03	NE	1.48E-02
Lead	11.7	21	3.34E-04	NE	6.00E-04	NE	3.34E-04	6.00E-04	6.00E-04	5.57E-01	1.00E+00
Manganese	88.68	489	2.53E-03	NE	1.40E-02	NE	2.53E-03	1.40E-02	2.20E-01	1.15E-02	6.35E-02
Mercury	NA	0.94	NE	NE	2.60E-05	NE	NE	2.60E-05	1.40E-03	NE	1.86E-02
Zinc	136.56	240	3.93E-03	NE	6.86E-03	NE	3.93E-03	6.86E-03	2.10E-01	1.87E-02	3.27E-02
TOTAL										6.07E-01	1.19E+00

000281

Table 6-38 (continued)

Daily Intake and Risks Associated with Exposure to Groundwater
Off-Site Deep Wells at the Dorney Road Landfill Site

Future-Use Scenario

Dorney Road RI

[a] Chronic daily intake (averaged over a 70-year lifetime for carcinogens, averaged over the exposure period for noncarcinogens) is the sum of the daily intake from the ingestion of drinking water pathway and from inhalation of volatilized chemicals during showering. Drinking water intake calculated as follows:

$$CDI = \frac{Cw\ (2\ l/day)(1\ mg/1000\ ug)}{70\ kg}$$

where Cw = concentration in residential wells; geometric means used for average case and maximum concentrations used for maximum plausible case for both drinking water and showering. Inhalation exposure estimated according to the method of Foster and Chrostowski.

[b] Potency factors and reference doses are listed in Table 6-17.

NA - not applicable. Only detected in one sample, and use of one-half of the detection limit in calculating the mean results in a mean concentration that is less than the detection limit.

NE - not evaluated.

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6.4.5 Estimation of Cleanup Levels

In previous sections exposure pathways were described and chronic daily intake for each chemical and exposure pathway estimated based on-site conditions and assumptions about current and future use. Estimates of human risks were then derived. For estimates of extra lifetime cancer risk, the chronic daily intake (CDI) in multiplied by the unit potency factor. For estimates of risk due to noncarcinogenic effects, a ratio of CDI to the Reference Dose (RfD) is calculated. The assumptions used and estimates of daily intake and corresponding risks are presented in Tables 6-19 to 6-38.

An alternative approach is to estimate the concentration of a particular chemical in an environmental media (soil, groundwater, etc.) that would not pose an unacceptable risk should human exposure occur by that specified pathway. Under this approach, the concentration of a chemical is estimated so that the resulting chronic daily intake would not exceed a $1x10^{-6}$ extra human cancer risk or a hazard index, CDI:RfD, of one. These concentrations termed cleanup levels were estimated for two exposure pathways: (1) direct contact with soil under current-use and future-use conditions, and (2) residential use of groundwater.

Direct Contact with Soil. Direct contact with soil under both current and future-use scenarios is comprised of both a dermal absorption pathway and an incidental soil ingestion pathway. The chronic daily intake (in mg/kg/day) of a specific chemical is the sum of the amount of chemical absorbed dermally and the amount of chemical absorbed after ingestion of soil.

Under the current-use scenario (Section 6.4.4.1), the Dorney Road site is used for recreational purposes only. The area is used primarily for hiking and hunting. It was assumed that both teenagers and adults would use the area for hunting and consequently two sets of assumptions, an average case and a maximum plausible case, were developed for both teenagers and adults (Table 6-18). These assumptions concerned such parameters as the number of hunting events per year, body weight, dermal contact factor, absorption factor, etc.

For the future-use scenario, it was assumed that the landfill area had been converted to residential use. As described in section 6.4.4.2, it was assumed that a person would live in the area until the age of 18 (average case) or would reside in the area for their entire lifetime (maximum plausible case). The assumptions for this scenario are listed in Table 6-31. These assumptions include age-specific values for body weight, skin surface area, incidental soil ingestion, etc.

An estimate of the soil concentration of a particular chemical that would result in a one in a million cancer risk should exposure occur by way of a dermal absorption pathway from direct contact with soil is calculated by:

$$Cs = \frac{(Rc)(BW)(DY)(YL)}{(CD)(E)(Yr)(Z)(Abs)(q_1^*)}$$

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where

Cs = chemical concentration in soil (mg/kg)

Rc = extra lifetime cancer risk of $1x10^{-6}$

BW = average body weight in kg (age-specific)

DY = days in a year (365)

YL = years in a 70-year lifetime

CD = contact rate of soil (g/event)(age-specific)

E = number of exposure events per year

Yr = duration of exposure in years

Z = conversion factor (kg/1000 g)

Abs = dermal absorption factor (1% and 3% for average case and maximum plausible case, respectively)

q_1^* = chemical-specific unit potency factor in $(mg/kg/day)^{-1}$.

Estimates of soil concentration based on incidental soil ingestion are calculated as follows:

$$Cs = \frac{(Rc)(BW)(DY)(YL)}{(I)(AI)(E)(Yr)(X)(q_1^*)}$$

where

Cs = chemical concentration in soil (mg/kg)

Rc = extra lifetime cancer risk of $1x10^{-6}$

BW = average body weight in kg (age-specific)

DY = days in a year (365)

YL = years in a 70-year lifetime

I = amount of soil ingested (mg/event)(age-specific)

AI = absorption factor (15% and 45% for PAHs and PCBs under average and maximum plausible case; 100% for all other chemicals)

E = number of exposure events per year

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Yr = duration of exposure in years

X = conversion factor 10^{-6} (kg/mg)

q_1^* = chemical-specific unit potency factor in $(mg/kg/day)^{-1}$.

Since the risk associated with direct soil contact is the result of the sum of the amount of chemical ingested and the amount of chemical dermally absorbed, then the soil concentration, Cs, may be expressed as:

$$C_s = \frac{R_C}{q_1^*}\left[\left(\frac{(BW)(DY)(YL)}{(CD)(E)(YR)(Z)(Abs)}\right) + \left(\frac{(BW)(DY)(YL)}{(I)(AI)(E)(Yr)(X)}\right)\right]$$

Similarly, soil concentrations based on a chronic intake which would result in a Risk Reference Dose Ratio of 1.0 is estimated by

$$C_s = (R_N)\ (RfD)\left[\left(\frac{(BW)(DY)(YL)}{(CD)(E)(YR)(Z)(Abs)}\right) + \left(\frac{(BW)(DY)(YL)}{(I)(AI)(E)(Yr)(X)}\right)\right]$$

where

Cs = chemical concentration in soil (mg/kg)

R_N = a chronic intake/Risk Reference Dose of 1.0

RfD = the Reference Dose for a noncarcinogenic endpoint

YL = years in the exposure period.

All other parameters are as described previously.

Based on these equations and using the assumptions for direct soil contact under current-use conditions (Table 6-18) and future-use conditions (Table 6-31), and chemical-specific potency factors and References doses presented in Table 6-17, cleanup levels for each surface soil contaminant of concern are estimated. For noncarcinogens, soil cleanup levels are based on both the average case assumptions and maximum plausible case assumptions. For chemicals believed to be carcinogenic, soil cleanup levels estimated are based on maximum plausible case assumptions. Soil cleanup levels estimated are those which would result in extra lifetime human cancer risk of $1x10^{-7}$, $1x10^{-6}$, $1x10^{-5}$, and $1x10^{-4}$, corresponding to a range of risks from one in ten million to one in ten thousand. The cleanup levels under current-use assumptions for teenagers and adults are presented in Tables 6-39 and 6-40. For future-use assumptions, the cleanup levels are given in Table 6-41.

Table 6-39

Cleanup Levels Based on Residential Exposure
of Teenagers to Indicator Chemicals Present In Surface Soil[a,b]

Dorney Road RI

Chemical	Surface Soil Concentrations in mg/kg Based on Chronic Intake/Risk Reference Dose Ratio of 1.0		Surface Soil Concentrations in mg/kg Based on Upperbound Lifetime Cancer Risks			
	Average	Maximum	Risk 10E-7	Risk 10E-6	Risk 10E-5	Risk 10E-4
PAHs	NA	NA	2.96E-01	2.96E+00	2.96E+01	2.93E+02
PCB	NA	NA	1.75E-01	1.75E+00	1.75E+01	1.75E+02
Arsenic	NA	NA	3.60E+00	3.60E+01	3.60E+02	3.60E+03
Benzene	NA	NA	1.56E+01	1.56E+02	1.56E+03	1.56E+04
Chloroform	NA	NA	1.00E+01	1.00E+02	1.00E+03	1.00E+04
Bis(ethylhexyl)phthalate	NA	NA	9.76E+01	9.76E+02	9.76E+03	9.76E+04
Dieldrin	NA	NA	2.70E-02	2.70E-01	2.70E+00	2.70E+01
Bis(ethylhexyl)phthalate	3.58E+05	1.16E+04	NA	NA	NA	NA
Di-N-butylphthalate	2.33E+08	7.52E+06	NA	NA	NA	NA
Phenol	7.17E+05	2.32E+04	NA	NA	NA	NA
4-Methylpentanone	NA	2.88E+04	NA	NA	NA	NA
Chlorobenzene	4.83E+05	1.56E+04	NA	NA	NA	NA
Ethylbenzene	1.78E+06	5.78E+04	NA	NA	NA	NA
4-Methylphenol	8.96E+05	2.88E+04	NA	NA	NA	NA
Beryllium	1.67E+05	1.93E+04	NA	NA	NA	NA
Chromium	1.68E+05	1.93E+04	NA	NA	NA	NA
Copper	1.34E+06	1.54E+05	NA	NA	NA	NA
Lead	2.00E+04	2.32E+03	NA	NA	NA	NA
Mercury	4.68E+04	5.41E+03	NA	NA	NA	NA
Nickel	6.70E+05	7.72E+04	NA	NA	NA	NA
Zinc	7.03E+06	8.11E+05	NA	NA	NA	NA
Naphthalene	7.31E+05	2.38E+04	NA	NA	NA	NA
Thallium	1.34E+04	1.33E+04	NA	NA	NA	NA

Table 6-39 (continued)

Cleanup Levels Based on Residential Exposure
of Teenagers to Indicator Chemicals Present In Surface Soil[a,b]

Dorney Road RI

[a] The cleanup levels are based on direct contact with soil (the sum of the ingestion pathway and dermal pathway) as stated in Table 6-18.

[b] For noncarcinogens, cleanup levels are estimated based on average case and maximum plausible case assumptions. Cleanup levels for carcinogens are based on maximum plausible case assumptions only. Refer to Section 6.4.5.

NA - not applicable. Only detected in one sample, and use of one-half of the detection limit in calculating the mean results in a mean concentration that is less than the detection limit.

Table 6-40

Cleanup Levels Based on Residential Exposure of Adults to Indicator Chemicals Present in Surface Soil[a,b]

Dorney Road RI

Chemical	Surface Soil Concentrations in mg/kg Based on Chronic Intake/Risk Reference Dose Ratio of 1.0		Surface Soil Concentrations in mg/kg Based on Upperbound Lifetime Cancer Risks			
	Average	Maximum	Risk 10E-7	Risk 10E-6	Risk 10E-5	Risk 10E-4
PAHs	NA	NA	3.64E-02	3.64E-01	3.64E+00	3.64E+01
PCB	NA	NA	2.14E-02	2.14E-01	2.14E+00	2.14E+01
Arsenic	NA	NA	4.50E-01	4.50E+00	4.50E+01	4.50E+02
Benzene	NA	NA	1.91E+00	1.91E+01	1.91E+02	1.91E+03
Chloroform	NA	NA	1.22E+00	1.22E+01	1.22E+02	1.22E+03
Bis(ethylhexyl)phthalate	NA	NA	1.19E+01	1.19E+02	1.19E+03	1.19E+04
Dieldrin	NA	NA	3.80E-03	3.80E-02	3.80E-01	3.80E+00
Bis(ethylhexyl)phthalate	2.21E+05	1.45E+04	NA	NA	NA	NA
Di-N-butylphthalate	1.44E+08	9.39E+06	NA	NA	NA	NA
Phenol	4.42E+05	2.89E+04	NA	NA	NA	NA
4-Methylpentanone	NE	3.62E+04	NA	NA	NA	NA
Chlorobenzene	2.98E+05	1.95E+04	NA	NA	NA	NA
Ethylbenzene	1.11E+06	7.23E+04	NA	NA	NA	NA
4-Methylphenol	5.53E+07	3.61E+04	NA	NA	NA	NA
Beryllium	2.12E+05	2.46E+04	NA	NA	NA	NA
Chromium	2.12E+05	2.46E+04	NA	NA	NA	NA
Copper	1.70E+06	1.96E+05	NA	NA	NA	NA
Lead	2.55E+04	2.95E+03	NA	NA	NA	NA
Mercury	5.96E+04	6.89E+03	NA	NA	NA	NA
Nickel	8.52E+05	9.84E+04	NA	NA	NA	NA
Zinc	8.99E+06	1.03E+06	NA	NA	NA	NA
Naphthalene	4.52E+05	2.97E+04	NA	NA	NA	NA
Thallium	1.70E+04	1.70E+04	NA	NA	NA	NA

ORIGINAL (Red)

Table 6-40 (continued)

Cleanup Levels Based on Residential Exposure
of Adults to Indicator Chemicals Present in Surface Soil[a,b]

Dorney Road RI

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[a]The cleanup levels are based on direct contact with soil (the sum of the ingestion pathway and dermal pathway) as stated in Table 6-18.

[b]For noncarcinogens, cleanup levels are estimated based on average case and maximum plausible case assumptions. Cleanup levels for carcinogens are based on maximum plausible case assumptions only. Refer to Section 6.4.5.

NA - not applicable. Only detected in one sample, and use of one-half of the detection limit in calculating the mean results in a mean concentration that is less than the detection limit.

Table 6-41

Cleanup Levels Based on Residential Exposure to Indicator Chemicals in Future Surface Soil[a,b]

Dorney Road RI

Chemical	Surface Soil Concentrations in mg/kg Based on Chronic Intake/Risk Reference Dose Ratio of 1.0		Surface Soil Concentrations in mg/kg Based on Upperbound Lifetime Cancer Risks			
	Average	Maximum	Risk 10E-7	Risk 10E-6	Risk 10E-5	Risk 10E-4
PAHs	NA	NA	1.32E-02	1.32E-01	1.32E+00	1.32E+01
PCB	NA	NA	1.15E-02	1.15E-01	1.15E+00	1.15E+01
Arsenic	NA	NA	7.02E-02	7.02E-01	7.02E+00	7.02E+01
Benzene	NA	NA	9.09E+01	9.09E+02	9.09E+03	9.09E+04
Chloroform	NA	NA	5.85E-01	5.85E+00	5.85E+01	5.85E+02
Bis(ethylhexyl)phthalate	NA	NA	5.71E+00	5.71E+01	5.71E+02	5.71E+03
Dieldrin	NA	NA	1.44E+00	1.44E-01	1.44E-02	1.44E-03
Bis(ethylhexyl)phthalate	1.56E+02	1.02E+03	NA	NA	NA	NA
Diethylphthalate	6.24E+05	4.06E+04	NA	NA	NA	NA
Phenol	3.12E+04	2.03E+03	NA	NA	NA	NA
4-Methylpentanone	NE	2.54E+03	NA	NA	NA	NA
Chlorobenzene	1.80E+05	1.37E+03	NA	NA	NA	NA
Ethylbenzene	7.79E+04	5.07E+03	NA	NA	NA	NA
4-Methylphenol	3.91E+04	2.54E+03	NA	NA	NA	NA
Beryllium	5.35E+03	5.16E+02	NA	NA	NA	NA
Chromium	5.36E+03	5.15E+02	NA	NA	NA	NA
Copper	3.96E+04	3.81E+03	NA	NA	NA	NA
Lead	6.40E+02	1.50E+03	NA	NA	NA	NA
Mercury	1.50E+03	1.44E+02	NA	NA	NA	NA
Nickel	2.19E+04	2.05E+03	NA	NA	NA	NA
Thallium	4.29E+02	4.28E+02	NA	NA	NA	NA
Zinc	2.25E+05	2.17E+04	NA	NA	NA	NA

ORIGINAL (Red)

Table 6-41 (continued)

Cleanup Levels Based on Residential Exposure to Indicator Chemicals in Future Surface Soil[a,b]

Dorney Road RI

[a] The cleanup levels are based on direct contact with soil (the sum of the ingestion and dermal pathway) as stated in Table 6-31.
[b] For noncarcinogens, cleanup levels are estimated based on average case and maximum plausible case assumptions. Cleanup levels for carcinogens are based on maximum plausible case assumptions only. Refer to Section 6.4.5.

NA = not applicable. Only detected in one sample, and use of one-half of the detection limit in calculating the mean results in a mean concentration that is less than the detection limit.

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Focusing on PAHs, cleanup levels for a 10^{-6} risk are 2.3 ppm and 0.36 ppm based on current-use assumptions for teenagers and adults, respectively, and 0.13 ppm based on future-use assumptions.

Ingestion of Groundwater. Cleanup levels for surface soil and subsurface soils that would be protective of groundwater were also estimated. Under this scenario, it was assumed that groundwater was used as a residential source of drinking water and that chemicals present in the soil and subsurface soil have the potential to leach from these soils into groundwater. Cleanup levels in soil represent the concentration of a particular chemical that, should it leach to groundwater and subsequently be ingested as drinking water, would not result in an extra human cancer risk of $1x10^{-6}$ or a chronic daily intake Reference dose ratio of one.

First, the concentration of chemical in groundwater is estimated. For extra lifetime cancer risk the concentration is calculated as follows:

$$C_{we} = \frac{(BW)(R)}{(I)(X)(q_1{}^*)}$$

for carcinogenic chemicals, and

$$C_{we} = \frac{(BW)(R)(Rfd)}{(I)(X)}$$

for noncarcinogenic chemicals, where

C_{we} = concentration of chemical in groundwater in ug/l,

BW = body weight, assumed to be 70 kg,

R = extra lifetime cancer risk of $1x10^{-6}$ or a hazard index of one

I = daily intake of water assumed to be 2 l/day,

X = conversion factor 10^{-3} (mg/ug)

$q_1{}^*$ = unit potency factor in $(mg/kg/day)^{-1}$, and

RfD = Risk Reference Dose in mg/kg/day.

Then, the soil concentration of a contaminant that with leaching would result in the estimated groundwater concentration (i.e., the amount of chemical in groundwater that when ingested would result in less than a $1x10^{-6}$ extra lifetime cancer risk) is calculated. Concentrations of contaminants in bedrock can be predicted based on future leaching from waste materials by assuming an equilibrium partitioning between water and soil as described by Mills et al. (1985) by the equation:

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$C_{we} = Cs/R$

where

Cs = concentration of contaminants in waste (mg/kg), and
$R = 1 + b(Rd/f)$;

where

b = soil bulk density (2.7 g/ml),
f = water content (0.2, assuming a saturated medium), and
$Kd = Koc\ foc$

where

Koc = organic carbon partition coefficient and
foc = fractions of organic carbon in soil (2.3×10^{-5}).

By rearranging this equation to

$$Cs = (C_{we})(1 + b\ (Koc\ foc/f),$$

Estimates of soil concentrations (Cs) at cleanup levels can be estimated. These levels are based on drinking water ingestion only and do not consider exposures due to inhalation of volatile chemicals during showering or other residential water use. In addition, cleanup levels were estimated only for those chemicals with a Koc value.

Based on these equations and assumptions, cleanup levels for surface soil and subsurface soil contaminants are presented in Tables 6-42 and 6-43. Cleanup levels that represent a Chronic Intake/Risk Reference Dose of 1.0 or correspond to an upperbound extra lifetime cancer risk of 10^{-7} to 10^{-4} (one in ten million to one in ten thousand) are presented. Focusing on PAHs, a surface soil concentration of 5.20 mg/kg PAH, is estimated, upon leaching to groundwater, to result in an extra lifetime cancer risk of 1×10^{-6}.

6.5 SUMMARY AND RISK ASSESSMENT UNCERTAINTIES

This endangerment assessment addresses the potential impacts to human health associated with the Dorney Road Landfill site in the absence of remedial (corrective) action, and therefore, constitutes an assessment of the no-action alternative. This endangerment assessment follows EPA guidance for risk assessment in general and for Superfund sites in particular and is based primarily on the data generated during the Remedial Investigation. The salient features and conclusions of this risk assessment are presented below.

Table 6-42

Cleanup Levels Based on Lifetime Residential Exposure to Indicator Chemicals in Groundwater[a,b]

Dorney Road RI

Chemical	Surface Soil Concentrations in mg/kg Based on Chronic Intake/Risk Reference Dose Ratio of 1.0	Surface Soil Concentrations in mg/kg Based on Upperbound Lifetime Cancer Risks			
		Risk 10E-7	Risk 10E-6	Risk 10E-5	Risk 10E-4
PAHs	NA	5.20E-01	5.20E+00	5.20E+01	5.20E+02
PCB	NA	8.283-02	8.28E-01	8.28E+00	8.28E+01
Benzene	NA	6.90E-02	6.90E-01	6.90E+00	6.90E+01
Chloroform	NA	4.36E-02	4.36E-01	4.36E+00	4.36E+01
Diethylphthalate	4.06E+04	NA	NA	NA	NA
Phenol	2.03E+03	NA	NA	NA	NA
Chlorobenzene	1.04E+03	NA	NA	NA	NA
Ethylbenzene	4.70E+03	NA	NA	NA	NA

[a] Cleanup levels are derived by estimating the groundwater contamination using a soil leaching model that, when based on ingestion of 2 liters of water per day over a 70-year lifetime, would result in a risk of 10^{-4} to 10^{-7}. Cleanup levels are based on drinking water only.

[b] For noncarcinogens and carcinogens, cleanup levels are based on maximum plausible case assumptions only. Refer to Section 6.4.5.

NA = not applicable. Only detected in one sample, and use of one-half of the detection limit in calculating the mean results in a mean concentration that is less than the detection limit.

Table 6-43

Cleanup Levels Based on Lifetime Residential Exposure to Indicator Chemicals in Groundwater[a,b]

Dorney Road RI

Chemical	Subsurface Soil Concentrations in mg/kg Based on Chronic Intake/Risk Reference Dose Ratio of 1.0	Subsurface Soil Concentrations in mg/kg Based on Upperbound Lifetime Cancer Risks			
		Risk 10E-7	Risk 10E-6	Risk 10E-5	Risk 10E-4
PAHs	NA	5.20E-01	5.20E+00	5.20E+01	5.20E+02
Benzene	NA	6.90E-02	6.90E-01	6.90E+00	6.90E+01
Chloroform	NA	4.36E-02	4.36E-01	4.36E+00	4.36E+01
1,2-Dichloroethene	NA	3.86E-02	3.86E-01	3.86E+00	3.86E+01
Tetrachloroethene	NA	7.63E-02	7.63E-01	7.63E+00	7.63E+01
Diethylphthalate	4.76E+05	NA	NA	NA	NA
Phenol	9.82E+03	NA	NA	NA	NA
Ethylbenzene	4.70E+03	NA	NA	NA	NA
Toluene	1.15E+04	NA	NA	NA	NA
Xylenes (total)	4.89E+05	NA	NA	NA	NA
Di-n-butylphthalate	1.88E+05	NA	NA	NA	NA

[a] Cleanup levels are derived by estimating the groundwater contamination using a soil leaching model that, when based on ingestion of 2 liters of water per day over a 70-year lifetime, would result in a risk of 10^{-4} to 10^{-7}. Cleanup levels are based on drinking water only.

[b] For noncarcinogens and carcinogens, cleanup levels are based on maximum plausible case assumptions only. Refer to Section 6.4.5.

NA = not applicable. Only detected in one sample, and use of one-half of the detection limit in calculating the mean results in a mean concentration that is less than the detection limit.

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As part of the Remedial Investigation on which this assessment is based, samples were collected from surface water, groundwater, soil, and sediment on and near the Dorney Road site in areas potentially affected by the site. In addition, background samples and reference samples blanks were collected in each of these media. The analytical data for these samples were reviewed to determine which of the chemicals detected were present at concentrations above those which are considered to occur naturally (background). Those chemicals that were detected at concentrations above background were selected as chemicals of potential concern at the Dorney Road site. The presence of chemicals above background levels does not necessarily indicate that these chemicals are related to the landfill. But because it is difficult to definitively determine site-relatedness of chemicals in situations such as the Dorney Road landfill where the waste disposed are not completely defined, we have conservatively assessed the potential impacts of all chemicals that were detected at the site at levels above background and for which toxicity information is available. Both inorganic and organic chemicals were selected as chemicals of potential concern. In soils, 8 inorganics and 13 organics were selected.

The on-site surface soil was more highly contaminated than off-site surface soils. PAHs were present in on-site surface and subsurface soil, but absent in off-site surface soil. While most of the inorganics found in on-site surface and subsurface soil were also found off-site, the concentrations of chromium, copper and lead were substantially higher in on-site samples. In surface waters, only one organic chemical and three inorganics, lead, zinc, and manganese, were selected for evaluation. As with soils, many chemicals were common to on-site and off-site groundwater, but the concentrations of lead, arsenic, benzene, vinyl chloride, cadmium, and chromium were detected in much higher concentrations on-site. In residential drinking water, trichloroethylene, and tetrachloroethylene, were detected and evaluated.

Only those chemicals of potential concern for which adequate toxicity data are available were evaluated further in this assessment. Adequate toxicity data for use in risk assessment include environmental standards, criteria, or advisories that are potential ARARs (applicable or relevant and appropriate requirements for Superfund assessment), or critical toxicity values such as references doses (RfDs) for noncarcinogens, and cancer potency factors for carcinogens.

Potential pathways by which human populations could be exposed to chemicals of potential concern, currently and in the future, were identified and selected for evaluation. Identification and selection of pathways was based primarily on considerations of chemical migration and the current and hypothetical future uses of the site and surrounding area.

The environmental characteristics and the current land use of the Dorney Road site were evaluated to identify potential pathways by which human populations could be exposed to the chemicals of potential concern. Exposure to chemicals of potential concern via direct contact with soil, surface water, sediments, and seeps and residential use of groundwater (residential wells) were selected for evaluation under the current-use conditions.

ORIGINAL (Red)

Future-use scenarios were developed and potential future exposures were evaluated. The exposure pathways that may be complete and significantly contribute to risk in the future, but that are not considered pertinent under current sue of the site, are dermal contact and incidental ingestion of soil by future residents, workers, and recreational users of the site. Swimming and fishing in on-site ponds are not considered likely events. Exposure of future workers and recreational users was qualitatively evaluated. Other potential future exposure pathways were not evaluated because they were not complete or were not believed to contribute significantly to overall exposure and risk.

Risks from potential exposures were evaluated first by comparing concentrations of chemicals in the contaminated exposure medium (e.g., surface water, soil, and groundwater) at points of potential exposure with Federal environmental standards, criteria, or guidance that were identified as "Applicable or Relevant and Appropriate Requirements" (ARARs). ARARs were not available for all chemicals in all media, and therefore risks were quantitatively assessed for human exposures to chemicals of potential concern in surface water and in soil.

Quantitative risk assessment involves estimating intakes (doses) by potentially exposed populations based on the assumed exposure scenario. These intakes are then combined with reference doses (RfDs) or cancer potency factors to derive estimates of noncarcinogenic hazard or excess lifetime cancer risks, respectively, to the potentially exposed populations. For noncarcinogens, results are presented as the ratio of the intake of each chemical to its RfD, and as the hazard index, which is the sum of the ratios of the intake of each chemical to its RfD. If the value of the hazard index exceeds one, there is an indication that health hazards might result from such exposures. For carcinogens, the excess lifetime cancer risk was estimated, and a 10^{-6} risk level (i.e., one excess cancer per million population exposed for a lifetime) was used as a benchmark.

ARARs for the protection of human health were available for some chemicals of potential concern in groundwater and surface water. Mean and maximum concentrations of these chemicals in the shallow and deep off-site groundwater, residential well water and surface water were compared with the appropriate chemical-specific ARARs.

In groundwater, the maximum concentration of arsenic, barium, cadmium, chromium, manganese, lead, benzene, and vinyl chloride exceeded their ARARs. The geometric mean concentration of benzene and vinyl chloride also exceeded the ARARs. In residential well water, only the maximum concentration of trichloroethylene exceeded the ARAR, while in surface water, all chemicals detected were below their corresponding ARARs.

ORIGINAL
(Red)

Under current-use conditions estimates of risk were developed for direct contact with soil (surface), sediments, seeps, and surface water, and for exposure (by drinking water and showering) to contaminants in residential groundwater. Maximum plausible case estimates of extra lifetime cancer risk exceeded $1x10^{-6}$ ($4x10^{-6}$ and $3x10^{-5}$ for teenagers and adult) for the direct contact with surface soil pathway. Risks were derived primarily from the presence of PAHs and arsenic. Direct contact with sediments does not appear to pose a significant cancer risk and no carcinogens were detected in surface water or seeps.

Similarly, the hazard index exceeds one for the on-site soil pathway primarily due to the high concentrations of lead. Exposure to noncarcinogens by way of sediment, surface water and seeps all result in a hazard index of less than one. In residential drinking water levels of trichlorgethylene and tetrachloroethylene result in a combined risk of $2x10^{-5}$ under the maximum plausible case.

Under future-use scenarios, direct contact with surface soil and contact with groundwater was assumed to occur with residential use of the site. For soil exposures to future residents in the landfill area, the lifetime extra cancer risk is $9x10^{-7}$ and $9x10^{-5}$ for the average case and maximum plausible case primarily due to the presence of PAHs and arsenic. The noncancer risk hazard index again exceeds one for the maximum plausible case due to the high concentrations of lead, chromium, and nickel. On-site exposure to groundwater, assumed to be used for residential drinking water under a future-use condition, resulted in estimates of extra lifetime cancer risk of $9x10^{-3}$.

Summary

In summary, the above analysis indicates that any persons using the landfill as specified, and having direct contact with soils on a frequent basis, may experience excess lifetime cancer risks of greater than 10^{-6}. A summary of the potential risks associated with the site is presented on Table 6-44. Risks to future workers and recreational users may be less. Caution should be exercised in interpreting the above risk estimates. Although, in general, there are considerable uncertainties inherent in risk assessment and it is common to use conservative scenarios such as lifetime exposure (which is possible but not likely), there are several aspects of the above risk estimates, relating to the conditions and assumptions of exposure and the toxicity criteria, that add an additional degree of uncertainty. These are outlined below.

Discussion of Uncertainties

All risk assessments involve the use of assumptions, judgement, and imperfect data to varying degrees. This results in uncertainty in the final estimates of risk. The uncertainties affecting risk estimates will be discussed in the remainder of this section.

TABLE 6-44
SUMMARY OF POTENTIAL RISKS ASSOCIATED WITH THE DORNEY ROAD SITE
DORNEY ROAD RI

Exposure Scenario	Total Cancer Risks		Noncarcinogenic Hazard Index	
	Average	Plausible Maximum	Average	Plausible Maximum
Current Condition - Soil				
On-site Teenagers	2.39×10^{-8}	3.96×10^{-6}	<1	>1
On-site Adults	2.11×10^{-7}	3.19×10^{-5}	<1	>1
Current Conditions - Surface Water				
On-site Teenagers	NE	9.28×10^{-7}	<1	<1
On-site Adults	NE	1.68×10^{-5}	<1	<1
Current Conditions - Sediments				
On-site Teenagers	NA	1.19×10^{-10}	NA	<1
On-site Adults	NA	9.75×10^{-10}	NA	<1
Current Conditions - Leachate Seeps				
On-site Teenagers	NA	NA	NA	<1
On-site Adults	NA	NA	NA	<1
Current Conditions - Ground Water				
Residential Wells	7.14×10^{-6}	3.18×10^{-5}	<1	<1
Future Use - Soils				
Residents	8.51×10^{-7}	9.17×10^{-5}	<1	>1
Future Use - Ground Water				
On-site Wells	1.46×10^{-3}	9.61×10^{-3}	>1	>1
Future Use Ground Water				
Shallow Off-site	9.02×10^{-4}	4.23×10^{-3}	>1	>1
Future Use - Groundwater				
Deep Wells	1.47×10^{-4}	3.01×10^{-4}	<1	1
Future Use - Surface Soils				
On-site Workers	2.13×10^{-7}	1.97×10^{-5}	<1	>1
Future Use - Subsurface Soils				
On-site Workers	4.21×10^{-8}	8.83×10^{-3}	<1	<1

NA - Not Applicable
NE - Not Evaluated

ORIGINAL (Red)

Uncertainty in a risk assessment may arise from many sources including:

- Environmental chemistry sampling and analysis;
- Misidentification or failure to be all-inclusive in hazard identification;
- Choice of models and input parameters in exposure assessment and fate and transport modeling;
- Choice of models or evaluation of toxicological data in dose-response quantification; and
- Assumptions concerning exposure scenarios and population distributions.

Uncertainty may be magnified in the assessment through a combination of these sources.

In risk assessments in which considerable uncertainty is anticipated, a technique commonly employed to compensate for uncertainty is to bias the assessment in the direction of overestimation of risk. This is often termed a "worst case" or "conservative" analysis. The net effect of combining numerous conservative assumptions is that the final estimates of risk may be greatly overestimated.

Environmental chemistry sampling and analysis error can stem from the error inherent in the procedures, from a failure to take an adequate number of samples to arrive at sufficient areal resolution, from mistakes on the part of the sampler, or from the heterogeneity of the matrix being sampled. One of the most effective ways of minimizing procedural or systematic error is to subject the data to a strict quality control review. Even with all data rigorously quality assured, however, there is still error inherent in all analytical procedures, and it is still not possible to definitively determine if the sample is truly representative of site conditions.

The absence of environmental parameter measurement also contributes to uncertainty. Lack of site-specific measurements requires that estimates must be based on literature values, regression equations, extrapolations, and/or best professional judgement. Modeling errors can stem from a lack of validation or verification of the models. Typically an order of magnitude result is considered to be satisfactory for most complex modeling scenarios. Values for the input parameters used in these models will be based on site-specific information where available but many of the required input parameters would also probably be based on more general information presented in the scientific literature.

In almost all risk assessments, the largest source of uncertainty is in critical toxicity values (RfDs and cancer potency factors), and these uncertainties may significantly affect the magnitude of the risk estimates presented in an endangerment assessment. Health criteria for evaluating long-term exposures such as RfDs or cancer potency factors are based on concepts

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and assumptions which bias an evaluation in the direction of overestimation of health risk. EPA noted in its Guidelines for Carcinogenic Risk Assessment (EPA, 1986b):

> There are major uncertainties in extrapolating both from animals to humans and from high to low doses. There are important species differences in uptake, metabolism, and organ distribution of carcinogens, as well as species and strain differences in target site susceptibility. Human populations are variable with respect to geometric constitution, diet, occupational and home environment, activity patterns, and other cultural factors.

These uncertainties are compensated for by using upper bounds for cancer potency factors for carcinogens and safety factors for reference doses for noncarcinogens. At best, the assumptions used in an endangerment assessment provide a rough but plausible estimate of the upper limit of risk, i.e., it is not likely that the true risk would be much more than the estimated risk, but it could very well be considerably lower, even approaching zero.

In addition, there are varying degrees of confidence in the weight of evidence for carcinogenicity of a given chemical. EPA's (1986b) weight-of-evidence classification provides information which can indicate the level of confidence or uncertainty in the data obtained from studies in humans or experimental animals. Some of the uncertainties in the hazard evaluation are further compensated for by assuming that animal carcinogens behave as human carcinogens. The summation of the risks associated with all potential carcinogens tends to overestimate risk by including probable human carcinogens (Group B) with demonstrated human carcinogens (Group A).

There are also inherent uncertainties in determining the exposure parameters that are combined with toxicological information to estimate risk. For example, there are uncertainties regarding assumptions in estimating the likelihood than an individual would come into contact with contaminants originating at the site, the concentration of chemicals in the environmental medium of concern, and the period of time over which such exposures would occur. In general, conservative assumptions will be made in estimating exposure point concentrations and estimating chemical intakes.

All of these individual sources of error may be propagated into larger errors by mathematical combination in the risk assessment. For purposes of evaluating remedial alternatives under Superfund, however, risk assessment provides a method to compare risks associated with various exposure routes, and this information can then be used to determine if and how remedial actions should be taken.

7.0 IDENTIFICATION OF PRELIMINARY REMEDIAL ACTION

Preliminary remedial actions have been identified which address site-related problems in groundwater, soils, surface water, and sediments. These are presented by media in the following sections.

7.1 GROUNDWATER

The hydrogeology of the Dorney Road site is complex; but, in general, the groundwater flow has been defined sufficiently for use in the selection and design of appropriate remedial measures. Additional hydrogeologic information may be required by PADER and USEPA for verification purposes during the subsequent design phase of the selected alternative.

A summary of the potentially feasible remedial alternatives identified for groundwater and the engineering solutions or technologies comprising each alternative are presented in Figure 7-1.

To address the pump and treat or in-situ treatment alternatives, additional site-specific hydrogeologic data will be required. Additional wells will be required to better delineate the vertical and horizontal limits of the contaminant plume. Also additional wells, screened only in the deep portion of the aquifer, will be required to document water quality of the deeper portion of the aquifer. Additional pump testing of the water-table aquifer should be performed to define the radius of influence for proposed extraction wells. To support any of the potential feasible remedial alternative, the hydraulic connections between the perched aquifer and the water-table aquifer and between residual soils that extend into the water-table must be better understood.

Since the piezometric surface of the water-table aquifer is only inferred from wells located outside of the landfill, the installation of wells through the landfill may be necessary to better delineate on-site water-table aquifer gradients and to determine whether the perched system within the fill is actually hydraulically connected to the water-table aquifer.

7.2 SOILS

The analytical results of the surface and subsurface soil samples show that contaminated surface and subsurface soils are present throughout the site. A summary of the potentially feasible remedial alternatives identified for the onsite soils and the potential engineering solutions or technologies comprising each alternative are presented on Figure 7-2. The off-site soils were not identified as an operable unit requiring remediation.

The onsite containment alternative requires that the aerial extent and depth of contamination be better defined to determine the extent of the area required to be controlled by the containment devices (e.g., cap, slurry wall, etc.). Additional geology information will be required to define competent bedrock if slurry wall containment is selected as part of the containment system.

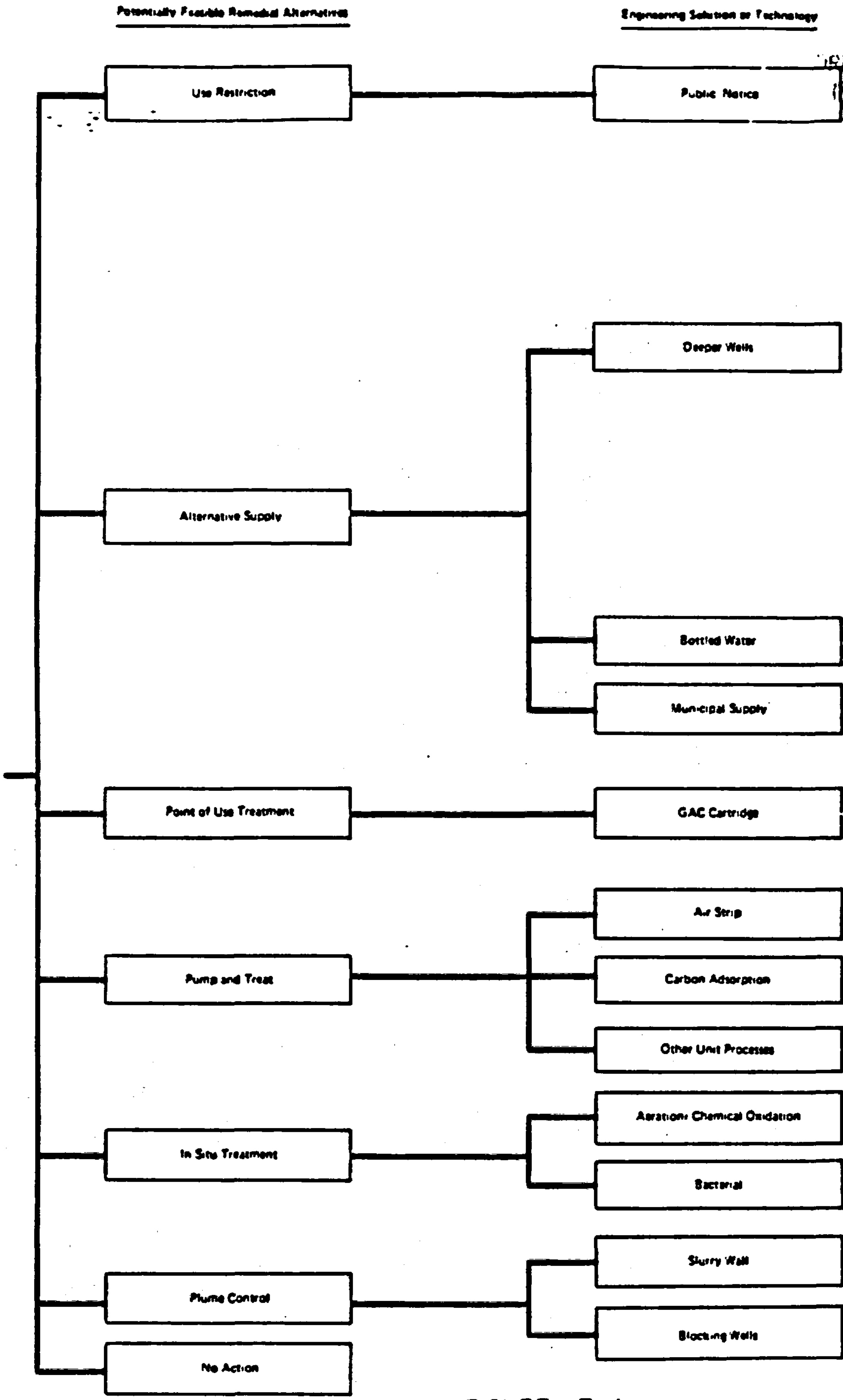

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FIGURE 7-1
GROUNDWATER OPERABLE UNIT
PRELIMINARY REMEDIAL ALTERNATIVES
DORNEY ROAD RI

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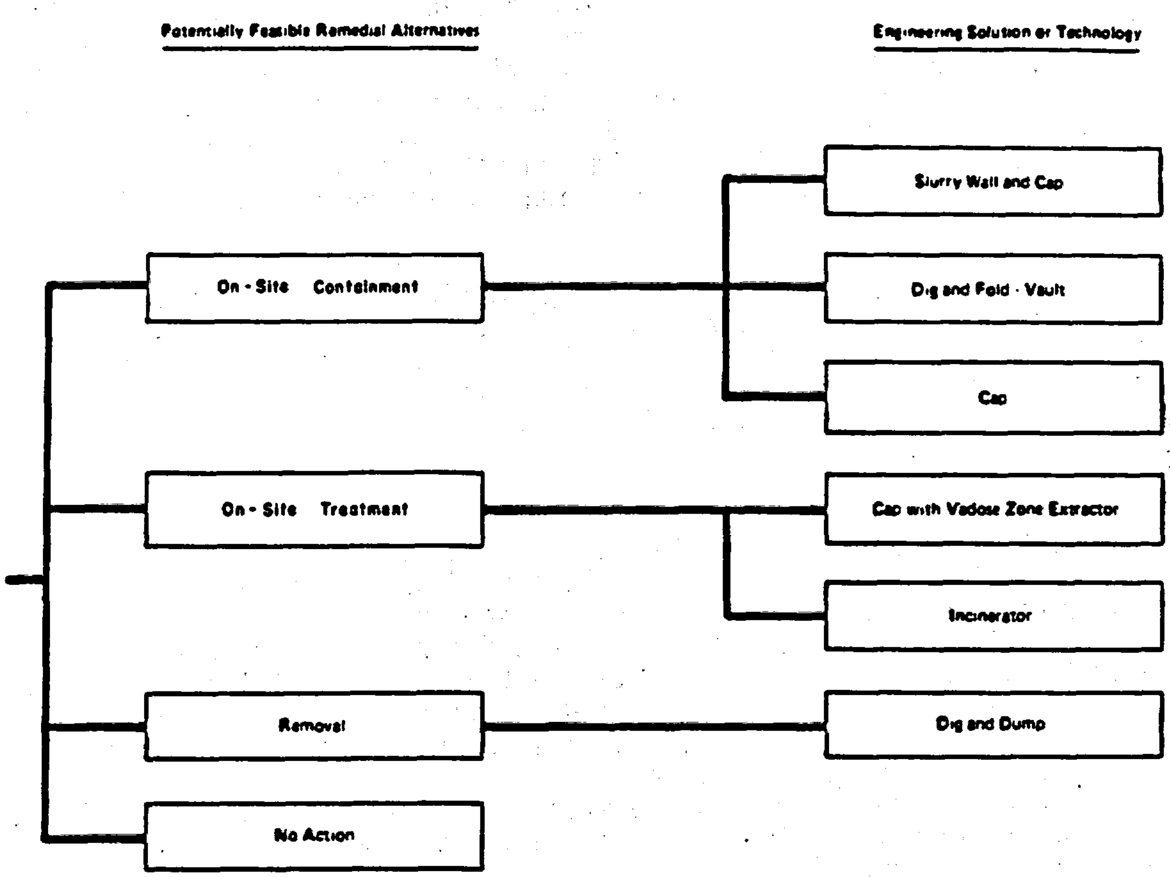

FIGURE 7 - 2
ON - SITE SOILS OPERABLE UNIT
PRELIMINARY REMEDIAL ALTERNATIVES
DORNEY ROAD RI

Alternatives that include treatment of the soils will require information on the types and concentrations of contaminants present in the soil, as well as the volume of contaminated soils. Further testing or bench scale testing may be required during the feasibility study to establish waste characterization (i.e., BTU, etc.) for selected treatment techniques.

7.3 SURFACE WATER

Based on the analytical results from the RI sampling, the surface water from the ponded areas of the site exhibit only low level volatile organic and inorganic contamination. Maximum concentrations were detected in the ponded areas located in the north central portion of the site and the small ponded area along the southern border. Discharge from the ponds occurs only during periods of high precipitation and spring runoff. Additional sampling to fully characterize surface water for the evaluation of treatment or disposal options may be required during the formulation and evaluation of remedial alternatives.

The volume of surface water requiring remediation will be needed during the evaluation of the treatment or removal remedial alternatives. A summary of the initial potentially feasible alternatives identified for the onsite surface water and the engineering solutions or technologies comprising each alternative are presented on Figure 7-3.

7.4 SEDIMENTS

The analytical data collected during the RI field activities indicate the onsite sediments associated with the ponded areas exhibit low level contamination. The presence of contamination appears to be related to erosion and deposition of the onsite contaminated surface soils as a result of surface runoff and transport. The potentially feasible remedial alternatives for the onsite sediments include removal and onsite containment. Additional data may be required to adequately characterize the thickness and chemical composition of sediments if removal is selected as the remedial alternative. A summary of the initial potentially feasible alternatives identified for onsite sediment and the engineering solutions or technologies comprising each alternative are presented on Figure 7-4.

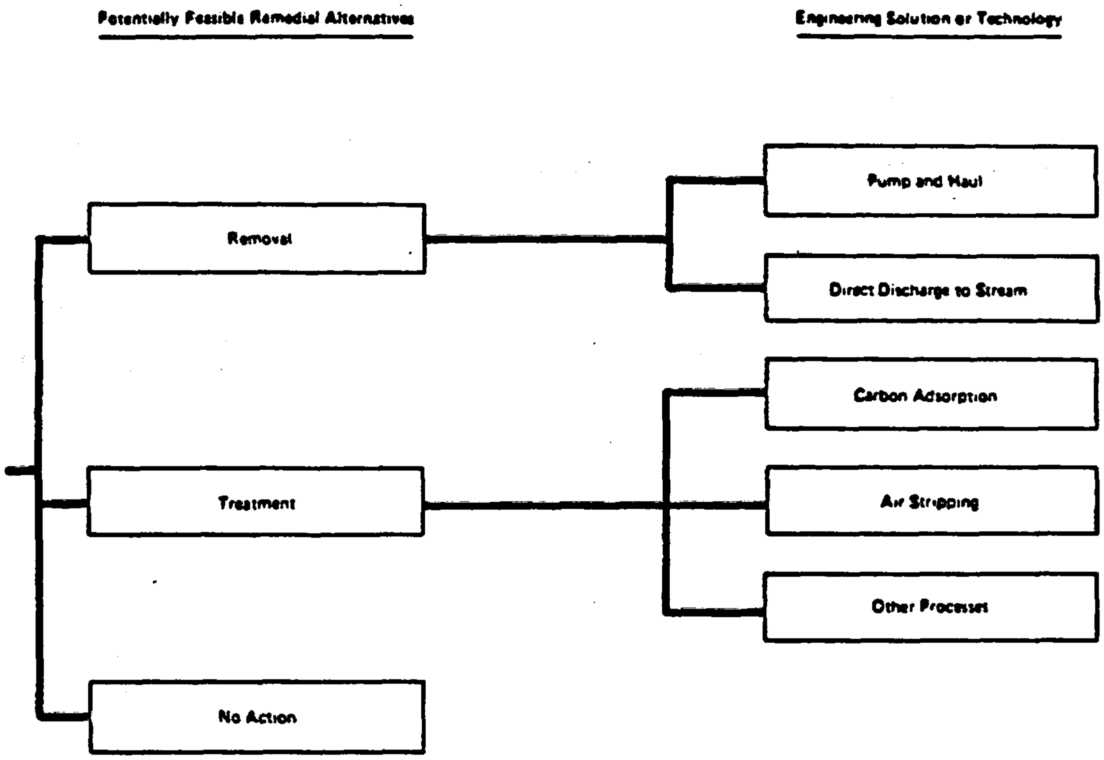

FIGURE 7-3
ON-SITE SURFACE WATER OPERABLE UNIT
PRELIMINARY REMEDIAL ALTERNATIVES
DORNEY ROAD RI

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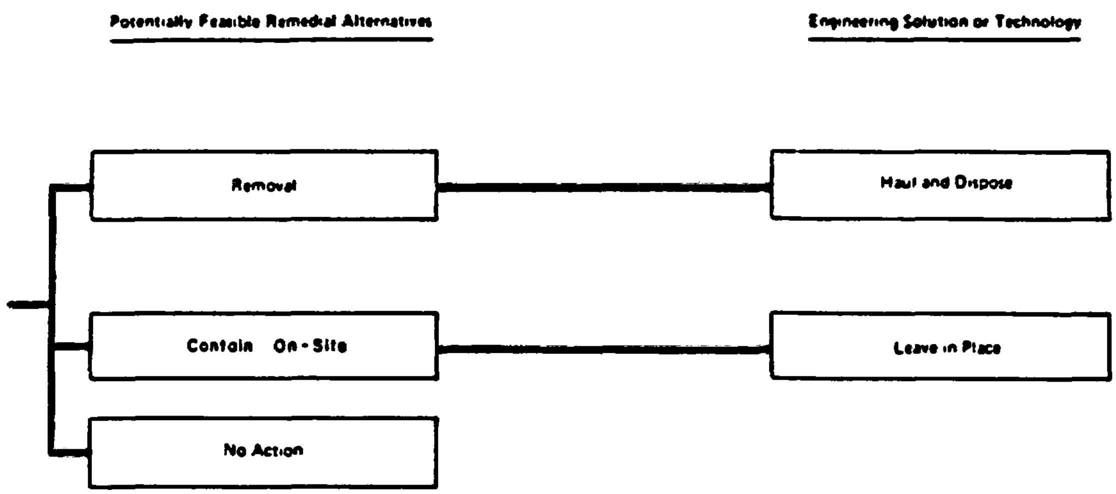

FIGURE 7-4
ON-SITE SEDIMENT OPERABLE UNIT
PRELIMINARY REMEDIAL ALTERNATIVES
DORNEY ROAD RI

AR000307

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